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THE RECORD STEEL PRODUCTION is claimed for the Edgar Thomson Steel Works, at Braddock, Pa., on the last run made on March 31, just before handing over the works to the U. S. Steel Corporation. In 12 hours the converting mill produced 1,995 tons of Bessemer steel in 133 heats, an average of 15 tons to the "heat." The best previous record was made at the same mill about two years ago, when 1,800 tons were produced in 120 heats, about the same average per heat. In this last record the ingots were rolled into 75-lb., 30-ft. rails as fast as produced; 3,195 rails being made in the turn.

AN OBJECT LESSON TO BRITISH WORKMEN, as to American methods of manufacture in the automatic tool industry, is proposed by the owners of a number of establishments in the Manchester district. These men have decided to send to the United States a picked body of British workmen, who will visit the American shops, study their methods and report to their fellow-workmen. In this way the promoters of this enterprise hope that British workmen may be convinced of the necessity of adopting the later and better practice in manufacture, if they wish to retain their work and their share of the world's trade.

DRAFTSMEN ARE WANTED by the Bureau of Yards and Docks, U. S. Navy Department, and examinations for applicants will be held at League Island, Pa., on April 16, and at Washington, D. C., on April 18. The Washington examination will be for two structural steel draftsmen at salaries of $5.04 per day, and applicants should address the Commandant, Navy Yard, Washington, D. C., on or before April 17. The League Island examination will be for draftsman-in-charge at a salary of $6 per day, and applicants should address the Commandant, Navy Yard, League Island, Pa., on or before April 15. The examinations will be practical in character, having reference exclusively to the requirements of the positions to be filled. The applicant's antecedents and experience, as well as the character of his previous work, will be duly considered by the board in making its recommendations. The board will make sufficient inquiry to ascertain that the applicants recommended are fit for the work; that they have enough education to make the required reports, estimates and calculations; that they are of reputable character, and of sober and industrious habits, and that they have not been convicted of crime or misdemeanor.

PLANS FOR A SUBMARINE TORPEDO BOAT are being prepared under the direction of the Naval Board on Construction, at Washington, D. C.; and these will be submitted, with an estimate of cost to Congress at its next session. The Board is opposed to the construction of submarine boats on the Holland plan. It seemingly favors a boat of the partly submerged or awash type; as presenting less resistance in making its way through the water with a speed of not less than 16 knots; that can be easily steered and more accurately discharge its torpedo. The Board holds that, without the expenditure of enormous power, it is difficult to secure a speed of more than 3 or 4 knots in a boat wholly submerged.

THE NEW TYPE 5-IN. NAVAL GUN was lately tested at Indian Head with satisfactory results. A 60-lb. projectile was used with 26 lbs. of powder, and the muzzle velocity reached 2,990 ft. per second, equivalent to a muzzle energy of 3,724 foot-tons. This record exceeds by 65% the muzzle energy of previous guns of the same caliber, and is sufficient to pierce 5 ins. of Krupp armor at 2,000 yds.; or, 7 ins. at the muzzle.

THE FAMOUS COLLIER "MERRIMAC," sunk by Lieutenant Hobson at the mouth of Santiago Harbor during the Spanish-American War, is being blown up, as it obstructs the entrance to the harbor. On April 6, 1,500 lbs. of dynamite were used to blow up the forward superstructure, and there is now 40 ft. of clear water over this part of the wreck. Mines are now being placed in the after portion of the ship, to be soon exploded.

LATE EXPERIMENTS WITH MAXIMITE, at Sandy Hook, are said to have been highly successful, though all details are withheld by the government officers. It is known that this maximite is a picric compound with certain other substances. The characteristic of maximite is that it is supposed to withstand without exploding the shock of penetrating armor-plate as thick as the caliber of the projectile, and yet can be exploded inside the armor-plate by a proper fuse. This maximite is poured into the shell in a melted state and then solidifies into a dense, hard block, impervious to powder-gases. The problem claimed to be solved is the finding of the proper detonator; and the one used at Sandy Hook is said to be perfectly satisfactory. A steel-faced target is being made for the ultimate test of this high explosive, and an improved Gathman 18-in. gun is already mounted at the proving ground to be used in this test. It is said that this Gathman shell will carry 700 lbs. of maximite, or 475 lbs. of compressed wet guncotton.

THE CONTRACT WITH THE BROWN SEGMENTAL Tube Gun Co. for 50 guns of 5 and 6-in. caliber has been cancelled by the Chief of Ordnance. Under the rigid government tests, it was found that while the high-muzzle velocity guaranteed by the company was secured, some of the test guns failed in other respects under 200 rounds, and all were found to be lacking in stiffness, owing to their construction. This gun is made up of segments forming a central tube, and around this tube is wrapped square steel wire of high tensile strength. As a result of this construction, the gun is so flexible that the muzzle deflects materially under the weight of the unsupported part, and the breech mechanism is also defective, as all the longitudinal strength is obtained from the segments alone.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Norfolk & Western Ry. at Sword's Creek, Va., on April 2. A double header freight train ran into a land-slide, resulting in the death of two men and the wrecking of both locomotives.

TESTS OF ELECTRIC RAILWAY MOTORS are now being conducted by the Manhattan Ry. Co., of New York city, for the purpose of selecting a motor to use in equipping its trains for electric traction. Motors have been furnished by both the Westinghouse and General Electric Cos. which surpass any motors previously built as regards both lightness and efficiency. In a recent test with one motor car and two trailers a speed of 44 miles per hour was attained and the acceleration was at the rate of two miles per hour per second.

THE FOOTWAY CABLES of the New East River Bridge, by means of which the main cables are to be built, are being erected. On April 9 the three strands composing the first of these temporary cables were hauled across the river and are soon to be raised and bound together into a single cable. There are to be four footway cables, two for each footway, and the method of erecting them is as follows: Three strands are first attached to the Manhattan anchorage and then passed over the adjacent tower, from the top of which they descend to three reels on a barge. By towing the barge across the river the strands are unreeled and sink to the river botttom. Upon reaching the Brooklyn shore the end of each strand is hauled to the top of the tower, and when all is ready is hauled in until it rises out of the water and spans the river at a height of 168 ft. above the water surface. When the three strands composing each cable have been thus stretched, they are bound together and the cable is complete. All four cables will be laid in this manner, and when completed, each pair will carry a footway platform from which the main cables will be constructed.

THE STOPPING OF A FREIGHT TRAIN MIDWAY in the Cascade Tunnel, on March 25, resulted in the death of Engineer Bradley and the disabling of the whole crew from the effects of coal gas. The engineer, feeling that he was losing consciousness, stopped his train; and when the rescuing party arrived it found the engineer dead and the conductor, fireman and brakeman lying unconscious alongside the track. Chief Engineer John F. Stevens, of the Great Northern Railway, published a letter in our issue of March 28 denying previous newspaper rumors of trouble in this tunnel from lack of ventilation. Mr. Stevens writes us again, under date of March 30, and says that the report of the above accident is substantially correct; but he says that much of the trouble charged to lack of ventilation is really due to a combination of green firemen and the qualities of the coal used by the road. No inconvenience of any kind had been experienced from lack of ventilation, from the time the tunnel was opened to traffic until this last occurrence, and Mr. Stevens charges the results of this accident to the improper handling of the train.

SEWAGE POLLUTED WATER SUPPLIES have been held responsible for recent outbreaks of typhoid fever at New Haven, Conn., and Rock Island, Ill. It is said that 150 or more cases have been reported at New Haven, nearly all in a section of the city supplied from one storage reservoir. It is also said that three cases of typhoid occurred in a house in the drainage area of this reservoir and that the excreta from the patients was buried in trenches a short distance from one of the streams in the drainage area. At Rock Island the epidemic has been investigated by Prof. E. G. Smith, of Beloit, Wis., who has found that one of the pump wells receives polluted water by infiltration. He recommends that the slow sand filtration plant, owned by the city, be put in operation again, under careful supervision as to its efficiency.

DAMAGES FOR POLLUTING THE PASSAIC RIVER have been awarded against the city of Paterson by a jury in the Bergen Circuit of the Supreme Court of New Jersey. The plaintiff claimed that his ice business had been ruined by the sewage of the city and that some 3,000 tons of ice in storage had become unsalable, presumably on account of the agitation regarding the pollution of the stream. The jury awarded him $3,000 damages for the ice, but none for the injury to his business as a whole. It is said that the city will appeal the case; also that numerous damage suits will be brought by other riparian owners.

A WATER PARK IN THE BACK BAY BASIN, at Boston, to be formed by damming the Charles River, is again being discussed. The subject was investigated in 1894 by the Metropolitan Park Commission and the Massachusetts State Board of Health. The project was dropped, owing partly to the opposition to the proposal to form land for another row of houses beyond the present Beacon St. water front. The present plan omits this feature and is different in other particulars, including a proposal for movable dams or gates on the proposed Charles River dam. The only action contemplated at present is the appointment of a state commission to investigate and report on the subject. A large part of the land bordering on the portion of the water front included in this scheme is already reserved for park purposes, by either the Metropolitan Park Commission or the several municipalities in which it is located.

THE $26,000,000 CANAL IMPROVEMENT SCHEME now before the New York legislature has been condemned by the Canal Association of Greater New York, an organization made up of representatives of a dozen or more of the principal commercial organizations of New York city. The following resolution was adopted at a special meeting on April 8:

> Resolved, That we, the Canal Association of Greater New York, do hereby assert most positively our belief, based upon most careful study, that the so-called 1,000-ton barge canal is the minimum of improvement that should be undertaken, and that the expenditure of the money of the state on any less improvement would, therefore, be an unwise expenditure of the public funds.

The $26,000,000 improvement has also been condemned and the 1,000-ton barge canal is favored by the Knights of Labor of New York city. The New York State Grange and other farmers' organizations have also taken steps to oppose the pending bill.

BIDS FOR THE PROTECTED CRUISER "MILWAUkee" were opened at the Navy Department on April 4. This vessel is to have a displacement of 9,700 tons and a speed of 23 knots. The Union Iron Works, of San Francisco, made a straight bid of $2,825,000 on the department plans. The Cramps, of Philadelphia, put in two bids, one for a vessel of 8,800 tons and 22 knots speed, at $2,740,000, and the second bid was the same amount for a ship on the department plans, with a stipulation that the Secretary of the Navy should request Congress to raise the limit of cost of the ship up to $3,000,000. Under the original invitation for bids the limit of cost was $2,770,000 for Atlantic coast bidders, and $2,880,000 for Pacific coast bidders. The contract will be awarded to the Union Iron Works.

THE AGGREGATE TONNAGE OF AMERICAN VESsels, says the U. S. Commissioner of Navigation, is 5,164,839 tons, with 1,565,587 tons of this on the Great Lakes, or 30%. In 1891 our aggregate tonnage was 4,684,759 tons, with 24% of this on the Lakes. Of the iron and steel tonnage in the United States, 687,769 tons, or 43%, are represented by vessels on the Great Lakes, though, out of the 1,225 iron and steel vessels flying the American flag, only 322 are on the Great Lakes, with 763 on the Atlantic and Gulf coasts. Last year the aggregate Lake tonnage, up to the close of the fiscal year, June 30, 1900, was 1,565,587 tons.

MELAN ARCH BRIDGES OVER FALL CREEK, INDIANAPOLIS, IND.

The city of Indianapolis has for a long time carried a comparatively heavy burden of expense in paying for the repairing and repainting of its many bridges over White River and Fall Creek. About a year and a-half ago, therefore, it was decided by the city authorities, advised by their Engineer, Mr. B. J. T. Jeup, that it was advisable to replace gradually some of the present iron and steel bridges by permanent structures. The first bridges to be rebuilt were two over Fall Creek, on the lines of Illinois and Meridian Sts., located in one of the best residence sections of the city. Bids were asked for steel plate-girder, concrete-steel, and stone bridges. Concrete-steel bridges of the Melan type were finally chosen as combining the greatest carrying capacity, permanence and artistic appearance with the lowest cost. The lowest price bid for building the two Melan bridges was $105,340; the lowest for the stone bridges $140,996. Steel bridges, although somewhat lower in cost than the Melan bridges, were rejected on account of their inferior beauty and their temporary character. Besides a saving of about 23% in first cost, as compared with the lowest bids for stone bridges, in a section of the state where good building stone is abundant and cheap, the Melan bridges of the same total length gave a greatly increased waterway, which was much desired.

Both new bridges have three spans each, the one on Illinois St. replacing a two-span bowstring bridge much too weak for the two lines of electric railroad crossing over the bridge; the Meridian St. bridge replacing a single 200-ft. span through truss. The new bridges are only two city blocks apart, and are built according to essentially similar designs, varying merely in their width and some details. All the spans have a clearance of 74 ft. and a rise of 9½ ft. The curve of the intrados is three-centered. The axis of the arches have a skew of 70°, with the center line of each of the bridges. The piers are 8 ft. wide, resting on foundation courses of 10 ft. maximum width about 7 ft. below the river bottom. The abutments are 23 ft. wide. All exposed surfaces of the bridges, with the exception of the soffits of the arches, are faced with oolithic limestone, rock-faced, and the parapet walls are entirely of this material. The concrete is all gravel concrete; the sand and gravel were procured from the river bottom by means of sand pumps and separated by screening, and were afterwards remixed in proper proportions. Only Portland cement was used for the concrete. The composition of the concrete for the abutments, piers and spandrel and wingwall backing was 1 part Portland cement, 3 parts sand, and 6 parts of gravel, measured by volumes; that for the arches, 1, 2 and 4 parts, respectively.

According to the regular Melan arch construction, steel ribs were imbedded in the arch concrete, consisting of 10-in. standard steel I-beams, weighing 25 lbs. per foot, spaced 3 ft. c. to c. They were provided with bearing or anchor plates at the abutment ends, and corresponding rib ends of the adjoining arches were spliced together over the piers. The arches are 16 ins. thick at the crown, increasing in thickness slowly towards the springing lines, having a thickness of 21 ins. about 10 ft. from the springing lines, from where the increase is more rapid.

The spandrel walls were not provided with expansion joints, as is customary in cement-faced bridges, for the reason that any expansion cracks that might develop in the spandrel walls after the completion of the work would naturally follow the mortar joints between the face stones, and their possible appearance would, therefore, not be objectionable to the eye.

Sand and gravel were used as filling material up to the subgrade of the pavements, which was in the case of the Meridian St. bridge pumped out of the river bottom directly onto the bridge, allowing the water to drain off through the drain pipes provided for over the piers. Although this method was satisfactory in other respects, it took considerable time for the water to drain out, and consequently the fill on the Illinois St. bridge was deposited dry.

The total width of the Meridian St. bridge is 70 ft. between parapet walls, divided into two cement concrete sidewalks of 15 ft. width each, and a roadway 40 ft. wide paved with asphalt. The Illinois St. bridge is 10 ft. narrower, being 60 ft. wide, the two cement concrete sidewalks being 10 ft. wide each, and the roadway, paved with creosoted yellow pine blocks, 40 ft. wide. This bridge also accommodates the two electric railway tracks.

The contracts for the two bridges were in the hands of two different firms of contractors, and a natural and healthy rivalry resulted for the employment of the most efficient methods of construction, and the attainment of the best results. The contractors for the Meridian St. bridge, who started work some months before the other firm, handled all their material by the use of derricks, etc., and conveyed the mixed concrete through a trough conveyor about 60 ft. long, provided with trap doors, through which the concrete was dumped at desired points. On the Illinois St. bridge all the material, including the concrete, was conveyed by means of two cableways, two main cables, working independently of each other, being used on account of the width of the bridge. Both methods gave satisfactory results.

The use of the cableway conveyor caused an interesting impact test of the southern shore arch of the Illinois St. bridge. One of the stones forming the end posts for the parapets at the northern end, and weighing about 2½ tons, was being conveyed by cable across the bridge. When a little past the center of the arch the stone block fell, on account of the steel cable breaking, from a height of about 10 ft. on the bare arch, touching with one corner first. Investigation showed, with the exception of a slight indentation of the concrete surface, no damage of any kind had resulted. In conclusion, it is, perhaps, interesting to make the following quotation from the report of the Board of Public Works to the mayor of Indianapolis, dated Feb. 4, 1901,

"with the final completion of the bridges over Fall Creek at Meridian and Illinois Sts., we feel privileged to say that there are no more substantial, durable, convenient and handsome bridges anywhere than these two."

The Meridian St. bridge was started in March, 1900, and completed in September of the same year; the contractors, Messrs. Shover & Austin, being delayed a number of times by high water. The Hoosier Bridge Co. had the contract for the Illinois St. bridge, commencing work in June and

FIG. 1.—ILLINOIS STREET BRIDGE.

FIG. 2.—MERIDIAN STREET BRIDGE.

FIGS. 1 AND 2.—STONE-FACED MELAN CONCRETE-STEEL ARCH BIRDGES OVER FALL CREEK, INDIANAPOLIS, IND.
B. J. T. Jeup, City Engineer; Melan Arch Bridge Construction Co., New York, Consulting Engineers.

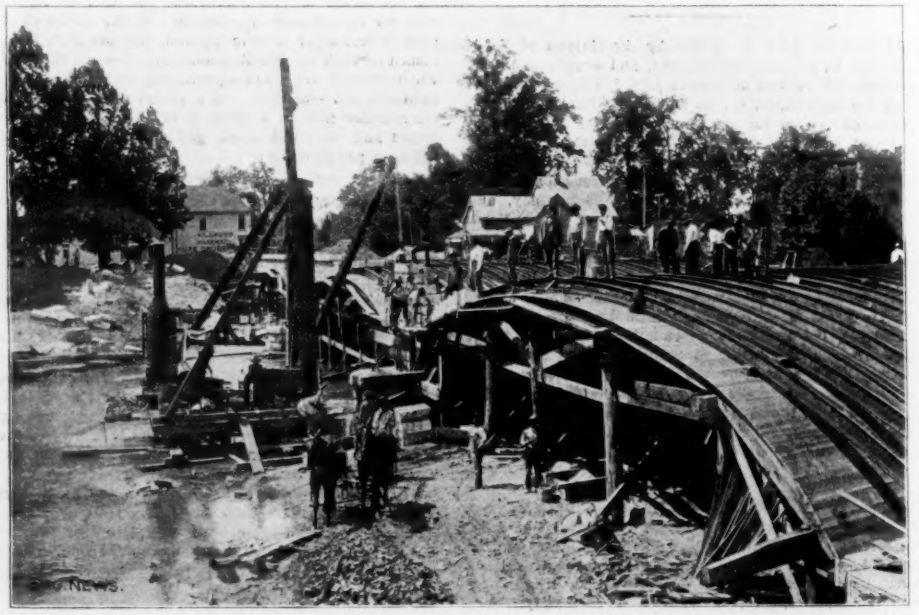


FIG. 3.—VIEW SHOWING MERIDIAN STREET BRIDGE IN PROCESS OF CONSTRUCTION.

finishing it in December of 1900. Both are Indianapolis concerns. Mr. B. J. T. Jeup, City Engineer, was in charge of the work for the city, and the Melan Arch Construction Co., of New York, the owners of the Melan patents, were the Consulting and Superintending Engineers, Mr. William Mueser representing this company in the capacity of engineer. To him we are indebted for photographs and data from which this article has been prepared.

STEEL BUILDINGS FOR EXPORT.

By H. G. Tyrrell.*

(With two-page plate.)

In the past few years a large export trade has been developed in American structural iron and steel. Bridges have been shipped from the United States to almost all countries of the world, including China, Japan, Egypt, Australia, Corea, New Zealand and the West India Islands, many of which have already been described in the enginering papers. This article has been prepared with the intention of showing some possibilities in steel building construction, and at the same time giving an approximate cost of the same, in order that makers may compare this style of construction with the cost of buildings made of brick and wood. These buildings, all of them the writer's own designs, have been prepared for export to foreign countries. Steel frames with corrugated iron covers are especially adapted to warm climates where artificial heating is not required. This accounts for many of them going to South America and the West India Islands.

Fig. 1 illustrates a foundry building for export to Denmark. It is 118 ft. by 230 ft. The width of 118 ft. is divided into one center bay of 54 ft. and two side bays of 32 ft. each. One side only is provided with a gallery floor of plank on steel joist. The center part is covered with a 30-ton traveling crane running the whole length of the building. The sides of the building have columns and brick curtain walls, and the roof is covered with corrugated iron. The weight of steel frame is 185 tons, which is equivalent to 14 lbs. per sq. ft. of ground covered. The total cost of the building complete, not including ocean freight, is $22,000 above foundations, which is equivalent to 80 cts. per sq. ft. of area covered.

Fig. 2 is a sugar warehouse for Porto Rico, to hold 20,000 bags of sugar piled up on two floors. It was necessary to have both the first and second floors of steel construction and fireproof. The covering of sides and roof is corrugated iron. The weight of the steel frame is 163 tons, and the total cost of building complete above the foundations is $17,000, which is $2.60 per sq. ft. of area covered.

Fig. 3 is a boiler house for Johannesburg, South Africa. It is 80 ft. × 130 ft. in plan and 16 ft. high to the eaves. The construction is entirely of steel and glass. This is a satisfactory building at the low cost of $6,100 complete above foundation and floor, which is equivalent to 60 cts. per sq. ft.

Fig. 4 shows a design for a foundry building, 80 ft. × 230 ft., and 20 ft. high to the eaves. The front end of this building facing on the street is built of brick. The rear end, two sides, and roof are covered with corrugated iron. Continuous sash 10 ft. high on the sides, together with a skylight on top of the ventilator provide ample light, and flat iron shutters give ventilation. One-half of the building is divided into machine, pattern, core and shipping rooms, and there is an office 40 ft. × 40 ft. on the street end. There is a system of trolley beams to carry two tons each, arranged to deliver material to large doors on the street. The total cost of this building above the floor and foundations is $12,900, which is equivalent to 85 cts. per sq. ft. of ground covered. The weight of the steel frame is 100 tons.

Fig. 5 is a two-story, eight-room, portable homestead for Porto Rico. It is provided with wide veranda to protect the house from sun. The upper story has a paneled steel ceiling, suspended. There is also an open space under eaves to allow a free circulation of air between the roof and ceiling of the second story. The whole frame is bolted together and may be taken apart and put up elsewhere without injury. The floor may be made either of wood or of two thicknesses of sheet iron, filled in between with clay or saw dust. The total cost of the building is $1,850, and total weight is 24 tons.

Fig. 6 is a two-story factory building, 50 ft. × 150 ft., having a steel frame. The walls are made of expanded metal and concrete. It has a plank and gravel roof. The intermediate floor has two layers of plank on hard pine beams, spaced 5 ft. apart. Its total cost is $10,100 for building complete, which is equivalent to $1.35 per sq. ft. of ground covered. The weight of the steel frame is 48 tons. The same building with 8-in. brick walls and steel columns and 8-in. curtain walls costs $11,000, or $1.45 per sq. ft. of ground covered.

Fig. 7 is a one-story storehouse, 50 ft. × 200 ft., with steel frame and sides made of expanded metal and concrete. It is lighted entirely from a skylight in the roof. This allows goods to be piled up against the walls. The height of the building to the eaves is 17 ft. It has a plank and gravel roof. The total cost of the building without any floor is $7,500, which is equivalent to 75 cts. per sq. ft. of ground covered. It contains 30 tons of steel. The cost of the same building with 8-in. brick curtain walls and steel columns is $8,200.

Fig. 8 is a cotton mill roof for export to Mexico. It is 45 meters wide by 90 meters long, and 5 meters clear height underneath the trusses. The walls on all sides are of brick, and the roof is covered with corrugated iron and glass. This form of roof admits all light from the north, and is the one commonly in use throughout the country for cotton mills. Its cost, not including either walls or foundations, is $15,200, equal to 35 cts. per sq. ft. of area covered.

Fig. 9 is a market house, 39 ft. wide and 481 ft long, for South America. It has a steel frame and the sides and roof are covered with corrugated iron. The two end houses are two stories in height. The central building is 26 ft. wide, with two overhanging portions of 6½ ft. each. It is lighted by continuous sash 3 ft. wide on each side above the doors. Ventilation is provided by means of wire netting 2 ft. wide under the eaves. There is a sliding door 5 ft. × 8 ft. in each panel. Its cost is $12,900, exclusive of ground floor and foundations, or 68 cts. per sq. ft. It is divided into stalls 10 ft. sq.

Fig. 10 is a workshop for South Africa. It is 52 ft. wide and 230 ft. long, and 20 ft. high to the eaves. It is made with 5 ridges, and is a very plain construction. The frame is steel, and the walls and roof are covered with corrugated iron. All the interior columns have brackets to carry shafting which are located above 3 ft. below the level of the underside of the trusses. The building is situated in a very exposed place, and was designed to withstand a wind pressure of 30 lbs. per sq. ft. on all exposed surface. The total weight of steel and sheathing is 80 tons, and the total cost above foundations is $8,200, equal to 68 cts. per sq. ft. of area covered. It has 400 shipping packages, and measures 9,000 cu. ft. on board ship.

Fig. 11 is a gold ore mill for Johannesburg, in South Africa. The mill is 83 ft. wide and 110 ft. long, and is covered on sides and roof with galvanized corrugated iron. Both the bottom and the sides of the ore pocket are lined with a 5-in. thickness of plank. The whole pocket contains 2,600 tons of ore. The steel frame weighs 300 tons, equivalent to 7 lbs. of steel for every cubic foot of contents. Its total cost is $37,000, or $2.60 per sq. ft. of area covered, which does not include the cost of either floor or foundation.

Fig. 12 is a market for export to Brazil. It is 50 meters square, and has streets on two sides only. It covers an area of 27,000 sq. ft. It is made entirely of steel and glass, excepting counters, which are wood. Ventilation is secured by means of louvres on the side of the monitors and continuous wire netting 2 ft. wide under the eaves. It has also a central tower covered on all sides above the main roof with louvres. Swinging shutters on the outside afford access to the stalls and form sun shades when open. The stalls are about 10 ft. sq. The weight of the steel frame is 76 tons, and the total weight of the entire building 118 tons. Its total cost is $11,900, which is 44 cts. per sq. ft. of area covered.

SHIPPING INSTRUCTIONS.

In order to estimate the probable space that this class of structural material will occupy when on board ship, it is the practice of the writer to consider all the pieces riveted up in the shop so far as possible into sections, not exceeding about 8 ft. in width and 30 ft. in length. These are the maximum sizes that can be conveniently piled on single cars of ordinary dimensions. When similar sections are piled in this manner, one above another, to a maximum height of say 8 ft., which is the greatest that the railroads will accept, it is then a very easy matter to figure the space occupied by this material. Short pieces, or such as packages or boxes of rivets, erection tools, etc., can easily be stored in the open space between truss members. As a general thing, therefore, it is necessary to figure only the space occupied by the large riveted sections. As the charge made by the steamship companies for freight depends, not only on the space occupied in the hold of the vessel, but also on the total number of pieces to be handled and the total tonnage of the whole shipment, it is necessary also to estimate the number of such pieces and packages. In order to have this number as small as possible it is desirable to tie up small pieces in as large bundles as can be conveniently handled. These are fastened together by means of wire, this being passed through rivet holes in the iron wherever possible to avoid the danger of loose pieces falling out. All bolts and rivets should be securely boxed, those of the same size and length going in separate boxes by themselves and having the size and length plainly marked on the outside of the box. As the shipping companies do their own loading, the iron company need figure only on delivering the material on the wharf alongside the vessel.

In reference to number of pieces to be handled, it is well to be very liberal in the estimate, as otherwise a great many more will be made than were originally figured on.

The method of marking large pieces is quite similar to that employed in the case of buildings for domestic use, each separate section having its own distinguishing mark on the erection drawing. In case of very large buildings where there are a number of loose pieces with a similar mark, it is desirable to bundle these by themselves and let the mark of each piece be the mark of the whole bundle.

Before making definite arrangements for the shipping of any structural material it should be definitely arranged with the steamship company in reference to the greatest length of pieces that they will accept, as many ocean liners will not take any greater lengths than about 40 ft. Corrugated iron can be tied in bundles, keeping sheets of the same gage and length in packages by themselves. As the cost of this material when erected in foreign countries is considerably greater than for similar buildings in America, owing to the expense of freight, it is customary to furnish galvanized iron rather than the ordinary black or painted iron. This, of course, does not occupy any greater bulk on shipboard, and will last probably twice as long as the ordinary kind.

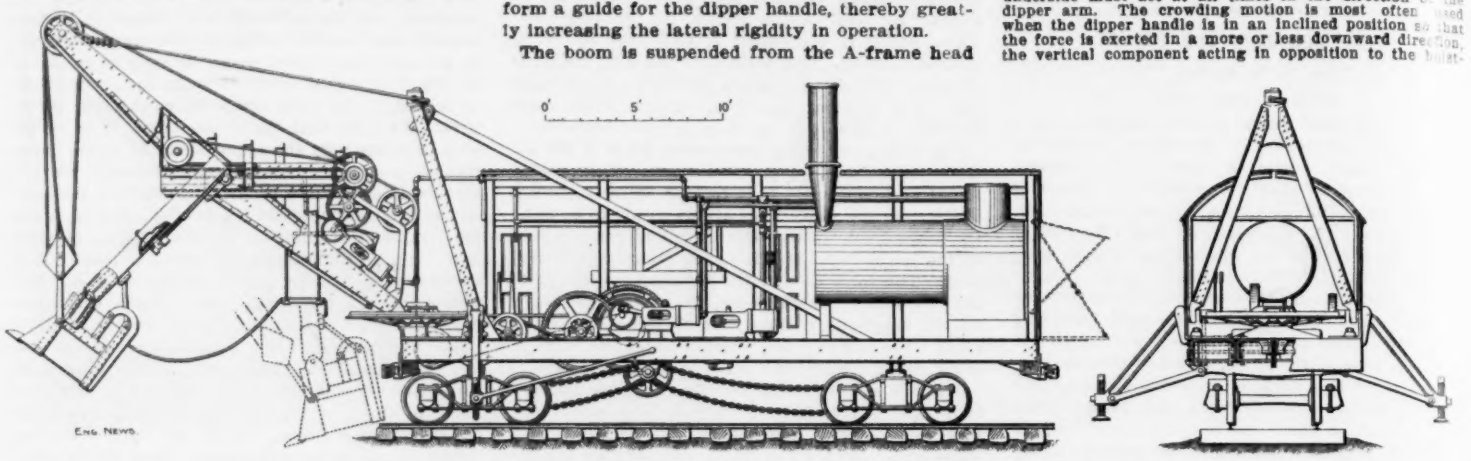
Very much greater care is required in the preparation of erection drawings for foreign use than for domestic, as the work is usually put together in the foreign country by local labor, with the assistance of one foreman sent on from America to superintend the work, and in many cases where buildings are small it will be found economical to have the entire work put up by local parties. As can easily be seen, however, great care will be required in the preparation of the erection plan to show the exact position of every separate piece, giving the size and length of all loose bolts, rivets, and all spliced plates, filling pieces, etc.

As all the foreign countries that are importing American goods will have some English-speaking people available for erection foreman, it will never become necessary to have the plans drawn up in any other than the English language. It will be necessary, however, to have these plans so plain that any good mechanic can understand them and erect the building according to them.

For convenience we will divide the whole cost to the purchaser into five parts, as follows: (1) Material manufactured complete at the contractors' works in America; (2) railway freight from

*Newton, Mass.

these works to American seaboard; (3) ocean freight to the foreign country, including both loading from the wharf in America and unloading onto the wharf again at the other end; (4) railway or other transportation expense from shipboard to the building site in the foreign country; and (5) erection expense. It is the practice of American manufacturers to make their price for material delivered at vessel, giving at the same time the total number of packages or separate pieces, and the cubic capacity of all the material when stored on board. Then the buyer, who is usually in the foreign country to which the material is going, will receive from the steamship company a price for ocean freight, and he can also include the transportation expense in his own country and cost of erection by local labor, all of which are more familiar to him than they are to the American manufacturer.



Sectional Elevation. End Elevation.

FIG. 1.—SECTIONAL SIDE AND END ELEVATION OF THEW STEAM SHOVEL; CLEVELAND, LORAIN & WHEELING RY.
The Thew Automatic Shovel Co., Lorain, O., Builders.

THE THEW STEAM SHOVEL; CLEVELAND, LORAIN & WHEELING RY.

A somewhat radical departure in steam shovel design is illustrated in the accompanying cuts of a shovel built in the early part of 1900 for the Cleveland, Lorain & Wheeling Ry., and used by that company during the greater portion of the season at the Massillon gravel pits. This shovel has recently been placed upon the market by the Thew Automatic Shovel Co., of Lorain, O., to whom we are indebted for the matter from which this description has been prepared. Fig. 1 is a sectional side elevation of the machine showing the general arrangement and construction of the various parts, and Figs. 2 and 3 are views of the shovel in operation at the Massillon gravel pits.

The chief feature of novelty in the machine is found in the construction of the swinging boom and the method of manipulating the dipper, particularly with reference to the crowding motion. The dipper arm is hinged to a carriage or trolley, which slides horizontally along a trackway forming part of the boom structure. The dipper is forced into the material to be excavated by advancing this carriage, thereby shifting the point of rotation for the dipper. This sliding carriage is of steel, with replacable friction shoes, and is actuated by wire cables operating over drums geared to the boom engine. Proper tension for the cables is secured by adjustment at the drums, which are double, one part being keyed to the shaft, the other loose with suitable provision for clamping to the fixed portion when in desired position. A throttle lever, manipulated by the cranesman, controls the movement of the trolley, a trip at each end of the horizontal stroke cutting off the steam automatically and obviating any danger from carelessness on the part of the operator.

The dipper arm is of rectangular cross section and adjustable as to length, the lower portion telescoping into the upper and being held in place by a lock which engages the teeth of a rack attached to the lower member. This lock is retained in position by a spring and is operated by means of a lever conveniently accessible from the cranesman's platform. The lock being released the length of arm can be adjusted by moving the trolley backward or forward as desired.

The combination of the boom with the trolley trackway is claimed to afford a very stiff construction, the slight clearance required for the upper end of dipper arm enabling the rigid cross connection of the two sides at frequent intervals. The boom girder is reinforced by Z-bars, which form a guide for the dipper handle, thereby greatly increasing the lateral rigidity in operation.

The boom is suspended from the A-frame head by wire guy cables. A further departure from generally accepted methods is found in the use of wire cables instead of chains for the hoisting and swinging motions. With sheaves of proper diameter it is claimed that most satisfactory results are secured, the decrease in friction and in the weight of operating parts being of considerable importance. Additional advantages which are claimed are the comparative noiselessness of operation and the lessening of unexpected breakage, wire cable in almost every instance giving ample warning of failure by its exterior appearance.

In stating these claims for this design of shovel the builders in a letter to us say:

> The design of the boom is based upon the theory that the work to be done represents the resultant of a vertical or hoisting movement necessary to lift the dipper through the material and of a horizontal or crowding movement to insure the complete filling of the dipper and increase the range of action without moving the shovel. In the usual designs of excavators the crowding motion is accomplished by lengthening the dipper arm, rotation taking place about a shaft stationary upon the boom. The thrusting power being applied by means of a rack on its underside must act at all times in the direction of the dipper arm. The crowding motion is most often used when the dipper handle is in an inclined position so that the force is exerted in a more or less downward direction, the vertical component acting in opposition to the hoisting motion and resulting in wasted power and unnecessary strains. The horizontal movement of the upper end of the dipper handle in this design secures the desired results in a most logical manner, by the direct horizontal application of the crowding force.
>
> It is further evident that the shifting of the point of rotation results in a more favorable lead for the hoisting cable, especially when the dipper is in its most unfavorable position near the front of the car body. Other advantages are found in the absolutely horizontal motion which can be imparted to the dipper for a distance corresponding to the trolley travel and ranging from 8 ft. to 9 ft. This permits a perfect leveling of the working floor, the removal of a maximum amount of material, and the laying of such a length of rail as to necessitate less frequent movement of the shovel. The method of manipulating the dipper further lends itself readily to the cutting of slopes within wide limits. The adjustment of dipper arm enables the machine to cut to any desired level within a variation of several feet. In practice it is found that once set for a desired working floor, occasion seldom arises for any alteration in the length of arm. This length being constant, the cutting edge can always be made to leave a clearance for the heel of the dipper avoiding an important source of friction and wasted power. The practical value of the design has been fully demonstrated not only in the excavator described, but also in single truck shovels of smaller capacity, of which a large number are now in use for handling ore, limestone and fuel in blast furnace yards and on the docks at Lake Erie ports, as well as in placer mining and general excavating work.

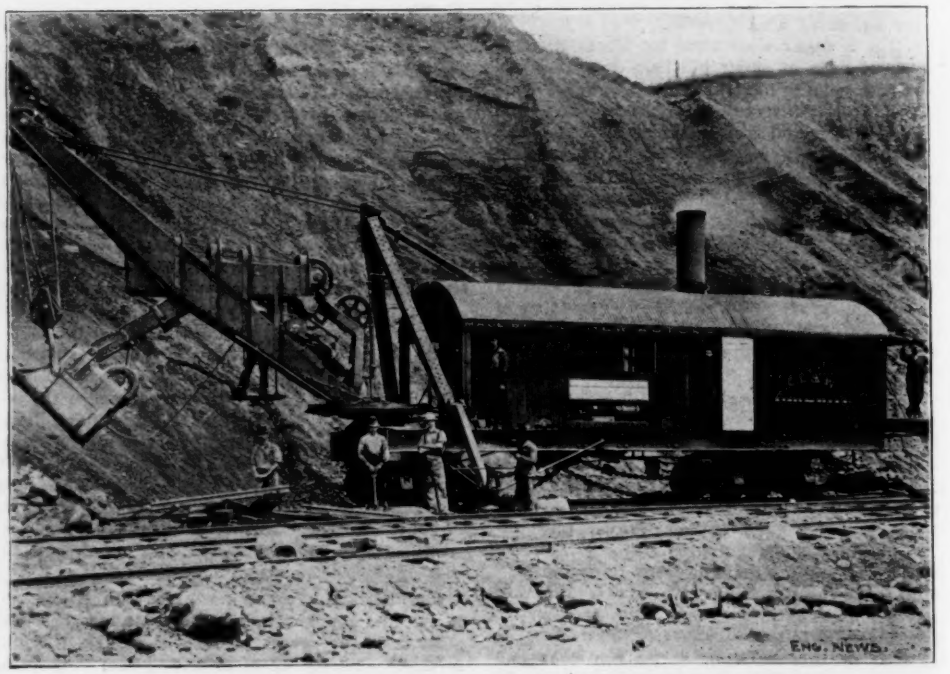


FIG. 2.—SIDE VIEW OF THEW STEAM SHOVEL; CLEVELAND, LORAIN & WHEELING RY.

In general construction the excavator is of the A-frame type, with independent reversing engines for the hoisting, swinging and crowding motions. Particular attention has been paid to the design of the car body, especially with reference to the rigid connection of the front portion of the car frame, which carries the turntable, boom, A-frame and jack stays, and which must withstand the severest strains of operation.

STATE HIGHWAY CONSTRUCTION IN NEW JERSEY IN 1900.

The seventh annual report of Mr. Henry I. Budd, State Commissioner of Public Roads, for New Jersey, records the work done, under the State Aid Road Law, for the year ending Oct. 31, 1900. In its detail of country characteristics and cost of construction for each road built under the law, this report keeps up the excellent features of those preceding it, and makes available a large amount of very useful and practical information on road construction. A large road map, showing the free and toll roads built in New Jersey under the law, is an instructive addition to the report, in showing at a glance where these improved roads are and how much has already been accomplished.

Mr. Budd states that the pressure for new roads is so great in New Jersey, that the people are constantly building ahead of the State appropriation; and last year, while the appropriation made only authorized the construction of 80 miles of road, about 140 miles of road were actually built or are under construction. In view of this public demand for highway improvement, Mr. Budd recommends an increase in the annual State appropriation, from $150,000 to $200,000; and he also suggests that the State Aid Law be so amended as to allow the counties to raise one-half instead of one-quarter per cent. upon their ratables. This latter amendment was once passed by the Legislature, but failed of approval; the present condition of the State treasury and the 30.3% rate of increase, shown by the last census, would now justify its re-enactment.

In explaining the increased cost of road construction in New Jersey, Mr. Budd says that the price of labor has advanced about 20%; the railways advanced their charges from 10 to 20 cts. per ton; and a combination among the quarry-owners made the average ton of stone in the road-bed cost at least 50 cts. more than the previous year's quotations. These increases have made the roads in the southern and central portions of the State, which are distant from stone quarries, cost fully one-third more than before. The lack of wisdom in the action of the quarrymen is already shown in a lessened demand for their product, and broken stone has fallen to 65 cts. per ton at some of the quarries, whereas the price fixed by the "combination" was $1.00 per ton.

In one county alone the Pennsylvania R. R. Co. transported 47,000 tons of crushed stone for State aided roads, and collected about $26,000 for freight, at 55 cts. per ton. The distance hauled did not average over 25 miles, and the advance of 15 cts. per ton over the rates of the previous year added about $7,000 to the cost of the roads. At the same time, the quarry supplying this stone—though not in the combination—charged 75 cts. per ton, or 25 cts. advance on the 40 to 50 cts. per ton charged in 1899. The general result was that the 83 miles of road actually built in 1900 cost an average of $5,384 per mile, instead of about $4,000 per mile in 1899.

The question of gravel vs. broken stone, for road construction in Monmouth Co., is being discussed, as a result of the increased cost of broken stone; and public sentiment seems to approve of the gravel construction, as being much cheaper—$1,499 per mile, as compared with $8,571 for stone; and as wearing well and being more cheaply kept in repair.

Mr. Budd points out that the tendency of improved roads and trolley lines is to scatter the population, and is gradually relieving the congestion of large cities. This is shown in the decrease of rentals near the centers of cities, from one-third to one-half, and the increased value of suburban property for rental purposes. Free rural mail delivery, recommended by the Postmaster General, will add to the advantages accruing from better roads.

The report states that while roads in different parts of the State are constructed of varying depths, some of telford and most of them of macadam, experience has shown that the most satisfactory roads are made with 6 ins. of macadam and 14 ft. wide. These roads are made of two layers of stone, each 4 ins. deep, rolled down to 6 ins. The engineers have adopted the plan of building these roads by block; or, placing cubical blocks, 4 ins. in size, and requiring all loose stone to be filled to the surface of the blocks. This method insures at a glance the proper depth of stone; and when so built, inspection by "plugging" shows that the roads always measure the full depth.

Embodied in the report are two contributions by Mr. R. A. Meeker, New Jersey State Supervisor, upon road materials and the maintenance of macadamized roads. As to materials, Mr. Meeker finds that, for heavy traffic, the New Jersey trap rocks, with the addition of a proper binding material, unquestionably hold the first rank. This trap rock, while it has but little binding property in itself, makes the best and most economical wearing surface. The article on road maintenance is full of useful hints, but its length compels us to refer those interested to the original text. Other special articles refer to the location of country roads; to the waste of power on grades; to tar macadam roads, as satisfactorily tested in Ontario; to the history of early transportation; to an inside history of the New Jersey State Aid Road Law, etc. The photographic illustrations of road conditions "before and after improvement," as shown in this report, tell their own effective story.

Any of our readers desiring copies of the report should address Mr. Budd, at Trenton, N. J.

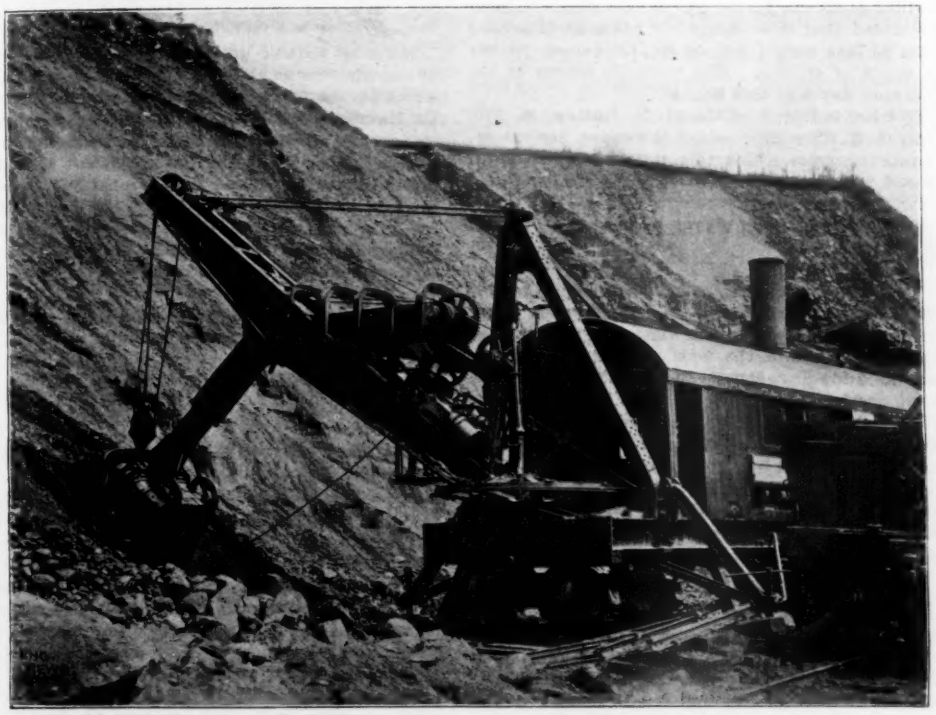


FIG. 3.—END VIEW OF THEW STEAM SHOVEL; CLEVELAND, LORAIN & WHEELING RY.

THE MUNICIPAL ASPHALT PLANT AT WINNIPEG, MAN.

There has been not a little agitation in some cities, of late, for the construction of municipal asphalt plants. In Winnipeg, Man., such a plant has been owned and operated by the city for about two years. Late in 1900 the city of Detroit awarded a contract for the construction of the second municipal asphalt plant in North America, and the first one in the United States, to Hetherington & Berner, of Indianapolis, Ind.

The first asphalt pavement in Winnipeg was laid by contract about four years ago. Before the beginning of paving work in 1899, the city bought the stationary asphalt plant erected there by one of the contractors for work previously done. The cost was about $12,000, but this included a five-ton steam road roller. The old roller proved to be too light for finishing the asphalt, so a ten-ton roller has been bought. The asphalt plant was moved to a new site, where additions and improvements were made. It has been used since for the work of 1899 and 1900. It appears that the chief difficulty encountered has been the securing of asphalt. It has been necessary to use several kinds, which, in turn, has called for much laboratory and experimental work.

The first asphalt used came from Ventura, Cal. The next was also a California asphalt, bought of J. A. Dubbs, of Pittsburg, Pa., and named by him "Obispo." A portion of the latter was crude, the maltha flux being added in Winnipeg, and a part of it was refined. After this, more Ventura and some Alcatraz asphalt was used. During 1900, Dundonald Trinidad asphalt was used, obtained from the Columbia Construction Co., of Philadelphia.

The plant includes two asphalt melting tanks, a sand drum, cold and hot sand elevators, millstone for grinding limestone,a storage tank for hot asphalt, storage bins for ground limestone and hot sand, a mixer of 7 cu. ft. capacity, a 60-HP. boiler, 30-HP. engine, air compressor and receiver and various accessories.

The regular force employed to operate the plant numbers an average of twelve men as follows: One superintendent, one engineer, two firemen, two asphalt melters, one asphalt dipper and mixer, one measurer of sand and carbonate of lime, one record keeper, one man for odd jobs, and an average of two sand and limestone shovelers. A daily expenditure of $40 covers the cost of operating the plant for a day of nine hours, and for producing material sufficient for 1,000 sq. yds. of 2-in. topping, or 1,500 sq. yds. of 1½-in. binder.

The cost of raw materials in 1900 was as follows: Portland cement in sacks, $3.65 per bbl.; asphalt, $36 per short ton; sand, $1.35, and broken stone, $1.10 per cu. yd., both on cars; labor, 17½ to 20 cts., and teams, 40 cts. per hour. The plant is located close by a railway line.

The net cost of 45,843 sq. yds. of asphalt paving laid in 1899 was $2.00, and the cost of 22,064 sq. yds. laid in 1900 was $2.064 per yd. This was for a 4½-in. Portland cement foundation, a 1½-in. binder and 2-in. wearing surface.

These unit figures of cost include only the expenditures for the material and labor used in paving, besides which there were charges for maintenance of the asphalt plant and for tools.

In addition, several other items should be taken into account in arriving at a figure of total cost comparable with that for similar work under contract, such as interest, depreciation, taxes, insurance, land rent, and both contractors' maintenance guarantee and profits.

It appears that the practice at Winnipeg has been to separate the asphalt accounts into capital,

maintenance and tools, the respective items for 1899 and 1900 being as follows:

Asphalt Accounts, Winnipeg, Man.—Expenditure on account of:				
1899.	Capital	$12,322		
	Tools	262		
	Maintenance	568	$13,152	
1900.	Capital	*733		
	Tools	121		
	Maintenance	†1,048	1,902	
				$15,054

*Chiefly for sand sheds and petroleum residuum tanks.
†Principally for replacing material which was defective when the city bought the plant. It is thought that such heavy items under capital and maintenance as were incurred in 1900 will not be required again, the plant now being in good shape for its present capacity.

It appears from the second foot-note to the table that the item entered under 1900 as maintenance should be charged, in part, to capital. Likewise, it is probable that a portion of the outlay for tools in each year should be so charged. In making up the figures presented below we have charged half of each of these three items to capital. Another charge against capital is the new steam roller. This cost $3,500, but we are informed that it is used more on macadam than on asphalt work, and that only one-third should be charged to the asphalt capital account. The teaming having been done by the hour it may be assumed that all the charges under that head are included in the 40 cts. per hour, already mentioned.

We may now attempt to determine at least some of the items that should be added to the figures already given as the cost of material and labor for asphalt paving in 1899 and 1900, in order to compare municipal and contract costs. The true capital account is first given, then the various items of current expense, as follows:

Capital Account.			
1899.	Original cost	$12,322	
	⅛ cost of road roller	1,200	
	½ cost of tools	131	
		$13,653	
	Depreciation at 5%	682	$12,971
Maintenance, Operation and Capital Charges.			
	Maintenance	$568	
	½ tools	131	
	Interest at 4% on $13,653	546	
	Depreciation at 5% on $13,653	682	
	Lost taxes	100	
		$2,027	
Capital Account.			
1900.	To balance	$12,971	
	New sheds, etc	733	
	½ tools	61	
	½ old maintenance charge	524	
		$14,289	
	Depreciation at 5%	714	$13,575
Maintenance, Operation and Capital Charges.			
	½ old maintenance charge	524	
	½ tools	60	
	Interest at 4% on $14,289	572	
	Depreciation at 5% on $14,289	714	
	Lost taxes	100	
		$1,970	
Summary and Averages.			
1899.	48,843 sq. yds. labor and material	$2.000	
	" " " capital, maintenance, etc.	42	
	Total per sq. yd., 1899	$2.042	
1900.	22,064 sq. yds., labor and material	$2.064	
	" " " capital, maintenance, etc.	89	
	Total per sq. yd., 1900	$2.153	

The item of $100 for lost taxes is the approximate amount paid to the city on the plant before its purchase from the former owners. A small rental fee for the land on which the plant stands is included under maintenance. Possibly insurance, if any is carried, is also included under that head. As to the rates of interest and depreciation, we are informed by the city engineer that the city pays 3½ to 4% on its loans and that depreciation may be reckoned at "between 5 and 10%; probably not much exceeding the former." Had we taken the highest instead of the lowest figure for depreciation it would have added only some 3 cts. per sq. yd. to the final result of our calculations.

To the revised figures of $2.04 per sq. yd. in 1899 and $2.15 in 1900 our readers may add such items as they think proper for contractor's guarantee and profits and for any contingencies not already considered or for which proper allowance has not been made.

It is interesting to note that two private contractors bid $2.7325 and $2.715 per sq. yd., respectively, for 16,800 sq. yds. of the pavement laid by the city in 1899, and that one of the same contractors offered to lay 28,300 sq. yds. of asphalt, on another street, for $2.47, after the city had decided to buy the asphalt plant.

In our issue of Feb. 21, 1901, we published a table by Mr. F. V. E. Bardol, of Buffalo, N. Y., showing the average cost of asphalt pavements in 47 cities, for the year 1900. In that table the cost for Winnipeg was given as $1.79, instead of the $2.064 cited at the beginning of this article, or the revised figure of $2.15. The discrepancy is explained by the fact that Mr. Bardol's figures for Winnipeg excluded grading and the cost of 3 ins. of gravel, beneath the concrete foundation, besides some other small charges.

The average reported cost of asphalt paving in the 47 cities was $2.29. On making various corrections for differences in local conditions a new average of $2.41 was secured, but the new figure for Winnipeg was reduced from $1.79 to $1.76, owing to higher local prices for concrete, which more than offset the lesser thickness of concrete foundation and wearing surface at Winnipeg and also Mr. Bardol's addition of 18 cts. to the Winnipeg figures to make up for the lack of the contractor's guarantee for maintenance. The standard for the latter was ten years, which Mr. Bardol valued at 18 cts. per sq. yd. of pavement. It may be added that the concrete in place at Winnipeg cost $5.7482 per cu. yd., or $0.7403 per sq. yd. for a depth of 4½ ins. Also that the length of the working day was nine hours.

We are indebted to Mr. H. N. Ruttan, M. Am. Soc. C. E., City Engineer of Winnipeg, for the information from which this article has been prepared.

FLOW OF WATER IN PIPES.

By Clinton B. Stewart, Assoc. M. Am. Soc. C. E.*

The writer has recently had occasion to review the literature of the subject of the flow of water in pipes, with the object in view of selecting from the available data the most reliable formula for use in designing distributing systems in waterworks construction. The results of the investigation are to be embodied in a new book on "Water Supply," to be published soon by Mr. F. E. Turneaure, Professor of Bridge and Sanitary Engineering at the University of Wisconsin. The results are thought to be of such practical importance as to justify their appearing in a publication which will reach a larger number of readers.

NATURE OF FLUID FRICTION.

The resistance to the flow of water through pipes may be considered as made up of two parts: (1) A loss of energy resulting from eddies produced in the water by irregularities in the inner surface of the pipe; (2) that due to friction of the water on the inner surface of the pipe.

Until recently the former, though taken account of by experimental coefficients, has been practically neglected as a cause of loss of head. When water flows through a pipe with a rough inner surface, a disturbance is caused in the stream of water, which may extend entirely through the mass; and it is the internal work of friction resulting from these eddies that constitutes by far the larger part of the total energy consumed in the flow. With a very rough inner surface, such as a riveted steel pipe, almost the entire loss of head is chargeable to internal friction due to eddies.

The relative importance of the two factors causing loss of head depends much upon the velocity of flow and diameter of pipe, as well as upon the roughness of the inner surface. For low velocities and small diameters the resistance is largely due to friction on the inner surface of the pipe, and varies closely with the velocity; but at ordinary and high velocities it is largely due to internal friction, and varies nearly with the square of the velocity. These relations, however, are much influenced by the roughness of the inner surface of the pipe.

GENERAL FORMULAS.

Owing to the variation in the general law, due to the variation in conditions, as already noted, it is impossible to derive a formula which will apply to all cases. The best that can be done is to select a form of expression which will approximately represent the law for the flow of water through clean wrought-iron and cast-iron pipes, and then to make use of coefficients by which the results of experiments may be conveniently expressed and utilized. The approximate law commonly used is that the loss of head varies as the square of the velocity, with the length of pipe, and inversely with the diameter, or,

$$h = f \frac{l}{d} \frac{v^2}{2g},$$

in which

v = velocity;
h = loss of head;
f = friction factor;
l = length of pipe; and
d = diameter.
g = acceleration due to gravity.

Tables giving values of (f) in this expression, for smooth cast-iron pipes, may be found in works on hydraulics. In practice the use of a coefficient (f) is somewhat inconvenient. A simpler and more commonly used form of expression, modified from the above, is the Chezy formula:

$$v = c\sqrt{r\,s};$$

in which

r = hydraulic mean radius;
s = hydraulic slope $\frac{h}{l}$; and
c = a coefficient.

The most reliable investigation and examination of experiments on the flow of water through clean wrought-iron and cast-iron pipes, is probably that by Hamilton Smith.* The results of his investigation are given in the form of tables and diagrams, giving values of the coefficient c, in the Chezy formula. These data probably represent the best available information on the subject; but for practical use the tables and diagrams are somewhat inconvenient, in that both the velocity and coefficient, c, may be unknown, the head being the known factor.

A formula which has been extensively used for cast-iron pipes is the Darcy formula,

$$v = \frac{1}{\sqrt{\alpha + \frac{\beta}{d}}} \sqrt{r\,s},$$

where α and β have the following values for English units:

For new cast-iron pipe $\alpha = .00007726$; $\beta = .00000647$.
For old or rough c.-i. pipe $\alpha = .0001545$; $\beta = .00001294$.

It will be noticed that the values of the constants for old pipe are double those for new pipe, which results in decreasing the velocity by about 30% for a given head, or doubling the loss of head for a particular velocity. Darcy's formula was derived from experiments on comparatively small pipes. For large pipes and high velocities it gives too small velocities. The experiments were most carefully made, but are open to some criticism from the fact that piezometers were used to measure very small losses of head.

Levy has modified Darcy's formula slightly, but the modification is too small to be of practical consequence.

Instead of using a variable coefficient, it has been proposed by some to adopt the formula,

$$v = c\, r^n\, s^m.$$

This form has the advantage of being easily solved by logarithms, and also of being platted and solved graphically. For clean cast-iron and wrought-iron pipes an equation of this form can be made to fit the experimental data, quite as well as those of the Chezy form. Two formulas of this class have been derived with special care and deserve mention, that of Lampe and that of Flamant. Lampe's formula in English units is,

$$v = 77.68\ d^{.634}\ s^{.555},$$

where d = diameter of pipe and s = slope.

Flamant, after making a careful examination of all the available experiments to date (1892), proposes the following formulas†: For new cast-iron pipe,

$$v = 86.38\ d^{\frac{5}{7}} S^{\frac{4}{7}};$$

and for cast-iron pipe, slightly incrusted, such as would nearly always be the case after a few years of service,

$$v = 76.28\ d^{\frac{5}{7}} S^{\frac{4}{7}}$$

*Anchor, Ill.

*"Hydraulics;" New York, 1886.
†Annales des Ponts et Chaussées. 1892.

Besides the above formulas and sets of coefficients, Kutter's formula, for the c in the Chezy formula, derived from experiments on flow in open channels, is frequently applied to pipes. The value of c is made to vary with a coefficient of roughness, n, the hydraulic radius and the slope. The value of n is taken according to the nature of the surface, being usually assumed at .011 for smooth pipes.

In the accompanying table a brief comparison is made of the various formulas:

Comparison of Various Formulas for the Flow of Water in Smooth Pipes.

Diameter, ins.	Slope.	Velocities in feet per second: Smith.	Lampé.	Flamant—New pipe.	Flamant—Pipes in use.	Darcy—New pipe.	Darcy—Rough pipe.	Kutter, n=.011
2	.004	1.07	1.05	1.02	0.90	1.20	0.85	0.79
	.05	4.54	4.25	4.34	3.83	4.24	3.00	2.78
	.20	9.68	9.17	9.59	8.46	8.47	5.99	5.57
6	.001	1.00	1.04	1.02	0.90	1.18	0.83	0.96
	.01	3.67	3.73	3.80	3.35	3.72	2.63	3.12
	.1	12.80	13.38	14.13	12.47	11.77	8.32	9.85
12	.0005	1.08	1.14	1.12	0.99	1.22	0.86	1.14
	.005	3.96	4.11	4.18	3.69	3.86	2.73	3.73
	.025	9.56	10.03	10.51	9.27	8.64	6.11	8.35
36	.0001	1.01	1.00	0.98	0.87	0.97	0.68	1.06
	.001	3.57	3.60	3.66	3.23	3.07	2.17	3.62
	.01	12.60	12.92	13.64	12.03	9.72	6.87	11.50
60	.00005	1.01	0.97	0.95	0.84	0.89	0.63	1.04
	.0005	3.51	3.49	3.55	3.13	2.82	1.99	3.57
	.005	12.50	12.54	13.22	11.66	8.92	6.31	11.45

An examination of the table shows that results by Smith's diagram, by the formulas of Lampe and by Flamant's formula for new pipes, all very closely agree. Flamant's formula for pipes in

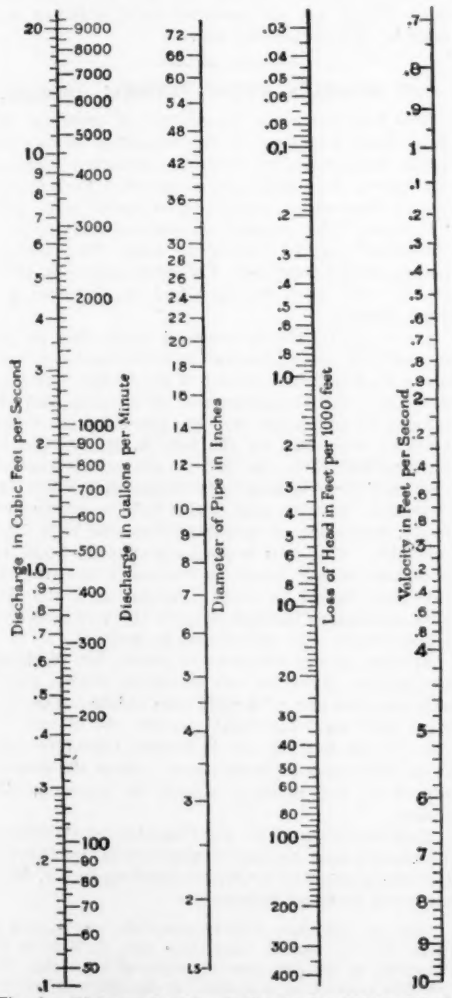

Discharge in Cubic Feet per Second
Discharge in Gallons per Minute
Diameter of Pipe in Inches
Loss of Head in Feet per 1000 feet
Velocity in Feet per Second

Fig. 1.—Diagram for Use in Designing Water-Works Distributing Systems.

service gives velocities about 10% less than by Smith's diagram; the loss of head would be about 20% greater. Darcy's formula for large-size pipes gives velocities considerably below the others. Kutter's formula, on the other hand, gives relatively low velocities for the small pipes, and thus, besides being complicated, does not fit the experimental data so well as some of the more simple forms; the experimental data are yet far too meager to justify such a complicated formula; the introduction of the effect of the slope on the value of c, especially for small slopes, as deduced from the experiments of Humphreys and Abbott on the Mississippi, is unreliable; and while not materially affecting the results for ordinary slopes, has made what would have been a comparatively simple formula, very complex.

DIAGRAM RECOMMENDED FOR USE IN THE DESIGN OF DISTRIBUTING SYSTEMS.

Among the various formulas mentioned, that of Flamant for cast-iron pipes in service is considered to be the most suitable for use in the design of ordinary distributing systems. It gives a slight margin of safety, which, in case the pipes are properly coated, will cover the deterioration for ten or fifteen years. The accompanying diagram, constructed after the principles laid down by M. Lalanne and M. Davies,* is based on this formula. On the four vertical lines are shown the four quantities, discharge, diameter, loss of head or slope, and velocity. The intersection of any straight line with these four vertical lines indicates corresponding values of these four quantities; so that any two being given the other two are determined by the application of a straight edge.

THEORY OF CONSTRUCTION OF DIAGRAM.

Let A x and B y, Fig. 2, be two parallel axes, separated by an arbitrary distance, A B; let A C and B D be values of x and y, respectively, on these axes, and satisfying the equations $a\,x + b\,y = z$; a, b and z being taken as constants.

Let A C′ and B D′ be other ordinates corresponding to x′ and y′, and satisfying the equation $a\,x' + b\,y' = z$.

Draw the lines C D, C′ D′, K H and P Z.

From similar triangles, and these two equations, the following results are easily deduced:

$$\frac{K\,M}{M\,H} = \frac{b}{a};$$

$$\frac{x - M\,P}{M\,P - y} = \frac{K\,M}{M\,H} = \frac{b}{a};$$

$$M\,P = \frac{z}{a+b}.$$

Thus the point M is a fixed point, and any line through this point will intercept values of x and y, which will satisfy the general equation $a\,x + b\,y = z$.

Now, taking z, also, as a variable, it is seen that by making the scale on the axis P Z in the ratio (a + b) : 1, values of z may be marked directly thereon, and any line will intercept values of x, y and z. Then, x and y being given, the corresponding value of z can be found on the axis P Z by drawing the line x y.

If the equation is of the form $a\,x - b\,y = z$, values of y must be taken in an opposite direction to those of x. If the scale for y is (n) times the scale for x the relation for the position of the axis z becomes:

$$\frac{K\,M}{M\,H} = \frac{b}{n\,a}.$$

The origins from which ordinates of x and y are measured may be any place on their respective axes.

For the flow of water through pipes, the equation for the diameter as a function of the discharge and velocity is:

$$D^2 = \frac{4\,Q}{\pi\,V};$$

or,

$$\log D - \tfrac{1}{2}\log\frac{4}{\pi} = \tfrac{1}{2}\log Q - \tfrac{1}{2}\log V.$$

Let,

$$\left[\log D - \tfrac{1}{2}\log\frac{4}{\pi}\right] = d;$$

$$\log Q = q;\ \log V = v,$$

and we have the equation:

$$d = \tfrac{1}{2}q - \tfrac{1}{2}v.$$

This equation can be represented graphically in the same manner as the equation $a\,x + b\,y = z$, and gives the relation between diameter, discharge and velocity. The equation for the diameter as a function of the discharge and slope, in the case of the Flamant formula for cast-iron pipes in service, is:

$$D = 0.2214\ Q^{\frac{3}{8}}\ s^{-\frac{1}{8}}.$$

Transforming by taking logarithms and plotting to the proper logarithmic scale, we will have

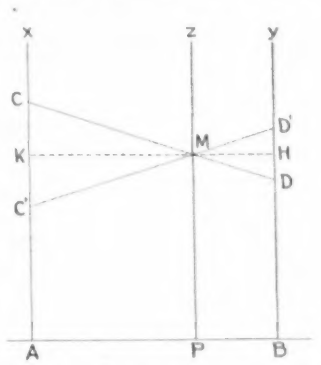


Fig. 2.—Sketch Illustrating the Theory of the Diagram.

the relation between the diameter, discharge and slope. The position and scale for the line showing velocity can be determined by a similar method, or graphically. Thus any line intersecting the four axes, discharge, diameter, slope, and velocity, will give thereon the respective value of each; and any two being given the other two are easily determined.

*"Nouvelle Annales de la Construction," August, 1897, and Darie's "Calcul des Conduits d'eau" (Paris).

THE NEW DINING CARS of the Chicago, Burlington & Quincy R. R., which were on exhibition in Chicago recently, are 70 ft. long over the end sills, and are mounted on six-wheel trucks. They are equipped with the Gold car-heating system and lighted by acetylene gas on the Adams & Westlake system, while the refrigerators are built on the Bohn system. The interior finish is in dark Flemish oak, with upholstering in red. The cars were built by the Pullman Palace Car Co., of Chicago.

HEAVY PASSENGER LOCOMOTIVES of the "Prairie" type (having six driving wheels, a leading pony truck and a single pair of trailing wheels) are being introduced on the Lake Shore and Michigan Southern Ry. Heretofore this type has been used only for freight service, having been first introduced about a year ago on the Chicago, Burlington & Quincy R. R. The new engines have driving wheels 6 ft. 8 ins. diameter; cylinders, 20½ x 28 ins., and weigh 174,500 lbs., with 130,000 lbs. on the drivers. This design enables a wide firebox to be used, the firebox being 7 x 7 ft., with 48½ sq. ft. of grate area to 3,343 sq. ft. of heating surface. The tubes are 19 ft. long, which is very exceptional. The engines are for the same service as the ten-wheel engines illustrated in our issue of Nov. 9, 1899, and resemble them in many respects, but the latter have fireboxes 10 x 3½ ft., and tubes 15 ft. long. The new engines were built by the Brooks Locomotive Works, of Dunkirk, N. Y., to the general designs of Mr. W. H. Marshall, Superintendent of Motive Power, L. S. & M. S. Ry.

DOUBLE-TRACK WORKING on parallel single track lines owned by different railways is being introduced at different points by the Cleveland, Cincinnati, Chicago & St. Louis Ry. The system is already in operation by cooperation with the Chicago & Alton Ry., between East St. Louis and Wann Junction, about 22 miles; also by cooperation with the Erie R. R., between Marion and Galion, O., about 22 miles. Interlocking plants are put in at the ends of the sections, and trains are run entirely by signal under telegraph orders from the dispatcher, no train orders being used. Semaphore signals of the three-position type are used; the horizontal position indicates "stop"; the downward inclination, "go ahead"; the upward inclination, "pull in on the next siding." The system works very satisfactory, with mutual benefit to both roads, as it increases the service and reduces the liability to accident. It is proposed to introduce it in a number of other cases where this road parallels others. On the Chicago Division a number of lap sidings are being put in to facilitate traffic; they are about 4,000 ft. long and five miles apart as an average, but are placed at the most suitable locations for the traffic, without regard to the location of the existing stations. Each siding has a signal tower, with signals and derails at each end of the siding. The "combination" double-track sections and the new lap sidings have been installed under the direction of Mr. Geo. W. Kittredge, M. Am. Soc. C. E., Chief Engineer of the C., C., C. & St. L. Ry.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

Two years' experience with a municipal asphalt plant at Winnipeg, Man., is recorded pretty fully elsewhere in this issue. After making allowances for capital charges and for the maintenance of the plant and its accessories, it appears that the asphalt pavements laid by the city in 1899 cost it $2.04 per sq. yd., and in 1900, $2.15. Of course these figures include nothing for contractors' profits, the saving of which was, presumably, one of the chief reasons for installing a municipal plant. Another item omitted here, but common to most asphalt work done under contract, is the maintenance guarantee. Allowing 18 cts. per sq. yd. for this, on the basis explained in our article, would bring the cost up to $2.22 for 1899 and $2.33 for 1900. But even these figures are well below the bids received by the city in 1899, for the very work subsequently done by it. As to the costs at Winnipeg, as compared with prices for asphalt elsewhere, it must be remembered that concrete is very expensive in that city, but this is partially offset by other factors, set forth in detail in the article. Altogether, the experience with the municipal plant at Winnipeg seems to be very gratifying. The results obtained this year will be awaited with interest, as will those which follow the installation of the new municipal plant at Detroit, Mich., the contracts for which were let a few months ago.

What will be the relations between the new billion-and-a-half United States Steel Corporation and its employees? It would not be strange if this proved among the most difficult questions which the managers of that corporation will have to face. Already it is stated that the Amalgamated Association of Iron and Steel Workers is at work on a proposition under which its executive committee is empowered to make agreements with the company for the settlement of all questions between it and its employees by a joint board of conference. This is, indeed, the only sensible plan for the treatment of this matter. The worst enemy of labor unions must acknowledge that when competition among employers of labor is ended—when the ironworker has only one place to go to obtain work—it is then farcical to claim that competition can still be relied upon to fix justly and equitably the wages and terms of labor.

If we take the other position—that the company has a right to ignore the unions, employ whom it pleases, pay what wages it chooses to pay and exact such services as it chooses to exact, it is at once clear that the company may reduce its employees, if it pleases, to a condition of practical slavery. It may force down wages everywhere to the starvation point, for those in its service will find it practically impossible to obtain employment elsewhere, and must take what the company will give them or remain idle.

Under these circumstances, the labor union must be admitted by every fair-minded man to be an economic necessity. When competition in the purchase of labor is wiped out, competition in its sale ought also to disappear. The United States Steel Corporation, then, will be compelled by the force of public opinion to meet and confer with the representatives of its employees; and that same force will strongly tend toward the granting by it of any reasonable demands. It may be safely predicted that the new corporation wants no strikes on its hands. It can afford to grant much to the unions rather than run the risk of their occurrence.

Had the Steel Corporation's directors only a single union with which to deal, their task would be fairly simple; but they have not one but dozens, covering the most diverse trades and occupations; and to adjust matters between these different organizations will be likely to prove a task of great difficulty. The rollers in the Carnegie mills, the coke burners in the Connellsville field, the iron ore miners on the Lake Superior ranges, represent, for example, three classes of labor, receiving very different rates of wages. The demand of the poorly-paid workers that they be put on an equality with the best-paid will be difficult to withstand, yet to scale all wages up to the level of the best-paid would make a large hole in the company's profits. To scale down the wages of the highly-paid workmen in Pittsburg, on the other hand, would bring down on the company the avalanche of public enmity and condemnation which it most desires to avoid.

While the worker for wages may feel fairly secure that the new consolidation will not result in his injury, the salaried man is by no means so certain. In former times, when conditions in one establishment became too grievous to be borne, the draftsman or foreman or superintendent was often able to better himself by a change to some other place. This avenue is now closed. Competition between employers, except for the few outside concerns, has disappeared. Competition for places is as brisk as ever. Will it be strange if the resident manager of a works, anxious to make a high record of profit, should use the lever of competition to force down the salaries of employees who have not the protection of a union back of them?

On the other hand, it is certainly true that the need for competent men of great executive ability is increased with each step in industrial consolidation. The possibilities of great economies through the harmonious co-operation of the concerns which compose the United States Steel Co. are certainly enormous; yet who shall work out the systems of direction that shall bring the best results out of each property without swamping the business in a mass of red tape? Perhaps the greatest danger before this corporation is that it may fail to offer such rewards and such security of position to its active managers as shall arouse their best and most loyal efforts. Individual initiative counts for a vast deal, even in these days of corporations and trusts. Official inertia has been the rock on which many a long-established concern has finally suffered shipwreck.

A commendable effort to extend the use of its schedule for uniform water-works statistics is being made by the New England Water-Works Association. That organization has printed the schedule in convenient blank form, so the various water-works officials who desire to use it need fill in the vacant spaces only, with the facts and figures indicated, then forward the schedule to their respective printers, with the other matter in script for their annual reports. The schedule is now used by a considerable number of works, but its value increases with the number who adopt it. It is not restricted to members of the association nor to public works. It is true, however, that most private works are not in the habit of making public such complete figures as are provided for in this schedule. While they have the benefit of all the municipal reports they give little in return. None deplore this fact more than some of the officials of private companies. We understand that a few of them have expressed an intention to use the schedule hereafter, making public such of the figures as they feel can be given out at the present time. Later on, we have little doubt, there will be far less secretiveness in this matter, for the public service corporations are now acknowledging their obligation to make public their operations. For the convenience of the many whom we trust will be interested in this matter, and who have not already received the blank forms, we would state that they may be obtained by addressing Mr. Chas. W. Sherman, Assoc. M. Am. Soc. C. E., Editor "Journal New England Water-Works Association," 1 Ashburton Place, Boston, Mass. It will do no harm to see what the forms are like even if they are not adopted, as it is hoped they may be, for immediate use.

THE BROOKLYN BRIDGE TERMINAL PROBLEM.

The long standing congestion of traffic at the New York terminal of the Brooklyn Bridge has again been brought to public attention through the report of a committee of the New York Chamber of Commerce, appointed to report some plan by which "the present dangerous and indecent crowding" may be done away with. The committee appointed consisted of Messrs. Abram S. Hewitt, M. Am. Inst. M. E.; Chas. A. Schieren and John Claflin.

Their report, briefly summed up, is that the responsibility and the power to devise and carry out plans for the improvement of the bridge terminals rest with the Commissioner of Bridges and the Municipal Assembly; that the plans for the bridge terminal proposed by the late A. M. Wellington, M. Am. Soc. C. E., in 1888 would have prevented, had they been adopted, the congestion which has ever since existed, and might now be advantageously made use of in remodeling the New York terminal. Finally it is proposed that the large expenditure which would be necessary to carry out this plan should be made a charge upon the railway companies instead of upon the city, and that legislation to this end should be secured.

As most of our readers are aware, Mr. Wellington, whose plans for the Brooklyn Bridge terminals are thus again brought into public notice, was from 1887 until his death in 1895 one of the editors of this journal. It is proper, therefore, that some discussion of these plans, and of the present aspect of the problem should be given in this place.

That the position of the Chamber of Commerce Committee may be clearly understood, we print in full the portion of its report relating to Mr. Wellington's plans as follows:

When the chairman of your committee was serving as mayor in 1887, serious complaints were made as to the congestion at the New York terminus of the bridge. He therefore assisted, as a member of the board of trustees of the bridge, in the passage of a resolution appointing a committee under the resolution, with power to select expert engineers to consider the whole subject and make a report to the committee for their consideration. After full consideration of the whole subject they made a report recommending the plans submitted by Mr. A. M. Wellington, a civil engineer of very distinguished reputation. The report of the board of experts was unanimously approved by the committee of the trustees and submitted to the board for their action. It does not appear that the trustees ever took definite action upon the plan thus submitted, but it was the subject of much discussion, both in

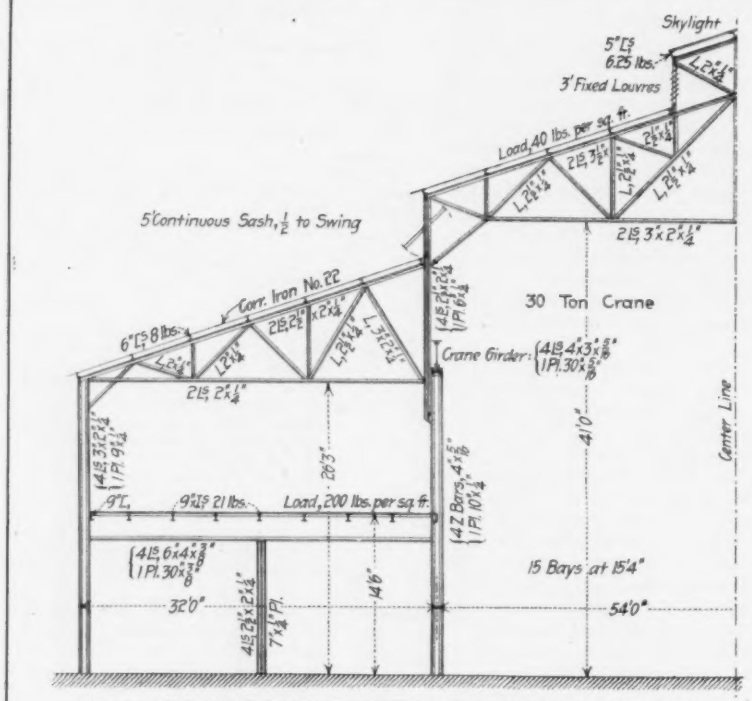


FIG. 1.—HALF TRANSVERSE SECTION OF FOUNDRY BUILDING FOR COPENHAGEN, DENMARK.

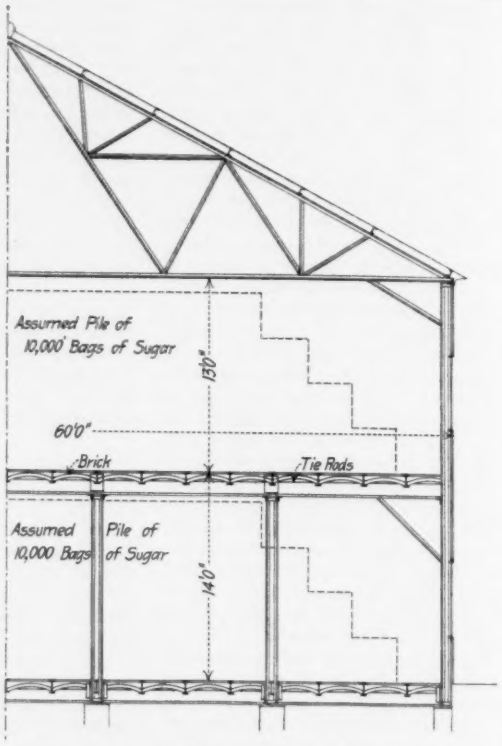


FIG. 2.—HALF TRANSVERSE SECTION OF SUGAR WAREHOUSE FOR PORTO RICO.

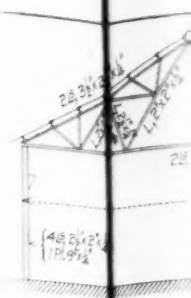


FIG. 3.—TRANSVERSE

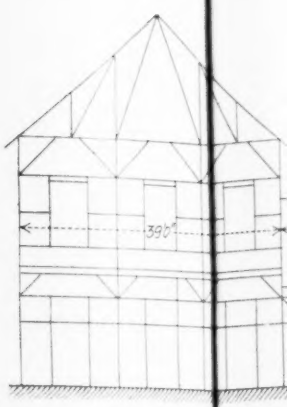


FIG. 9.—DIAGRAM ELEVAT

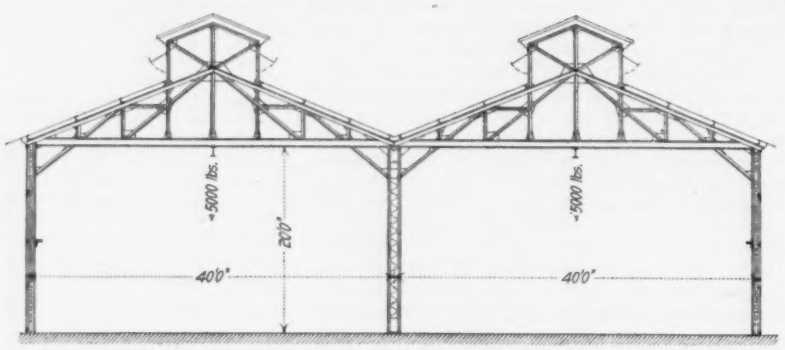


FIG. 4.—TRANSVERSE SECTION OF FOUNDRY BUILDING.

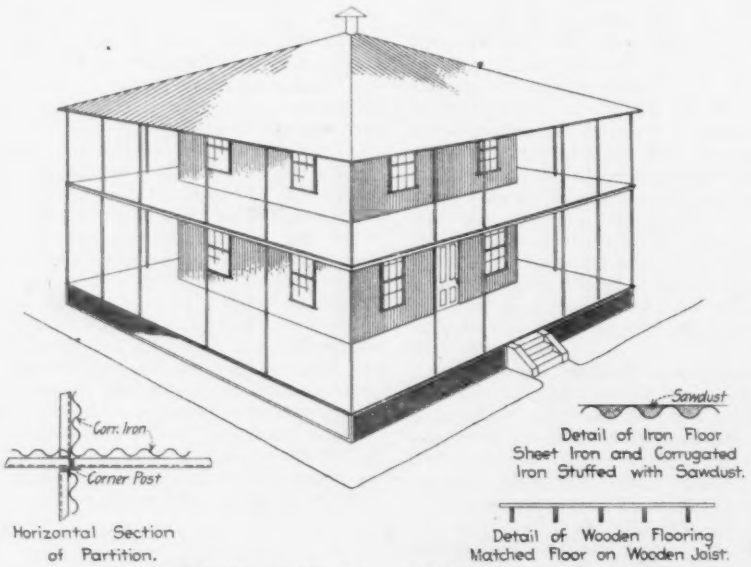

Corr. Iron
Corner Post
Horizontal Section of Partition.
Sawdust
Detail of Iron Floor Sheet Iron and Corrugated Iron Stuffed with Sawdust.
Detail of Wooden Flooring Matched Floor on Wooden Joist.

FIG. 5.—TWO-STORY PORTABLE HOMESTEAD FOR PORTO RICO.

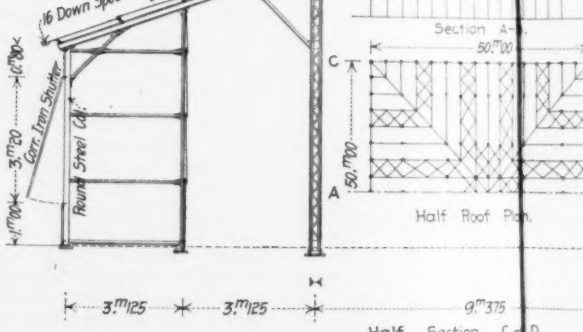

Roof Cover. Corr. Iron No. 22
16 Down Spouts 6 alv. Iron No. 22
Corr. Iron Shutter
Round Steel Col.
Section A-B.
Half Roof Plan.
Half Section C-D.

FIG. 12.—SECTION AND DIAGRAM FRAMING PLAN

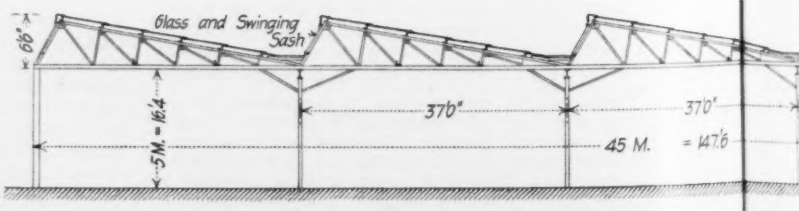
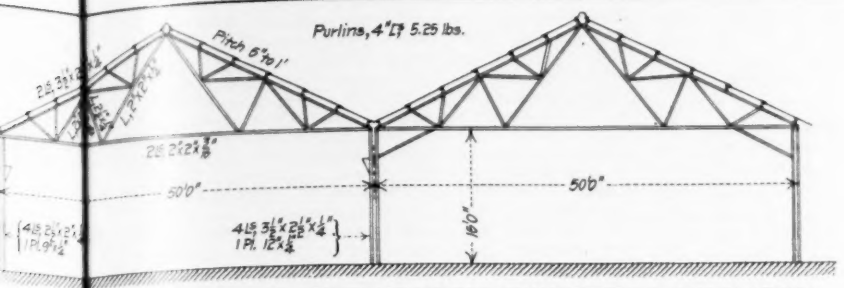


FIG. 8.—ELEVATION OF COTTON MILL ROOF TRUSS FOR ME

STEEL BUILDINGS FOR

H. G. Tyrrell, Newton, Mas



IG. 3.—TRANSVERSE SECTION OF BOILER-HOUSE FOR JOHANNESBURG, SOUTH AFRICA

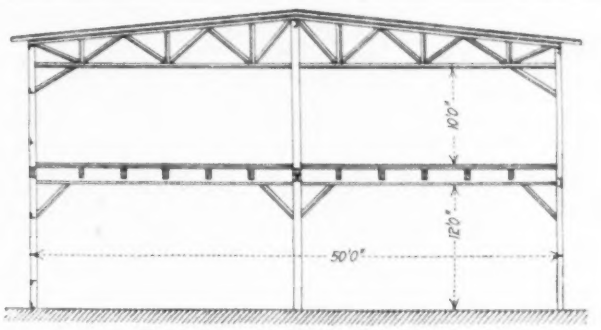
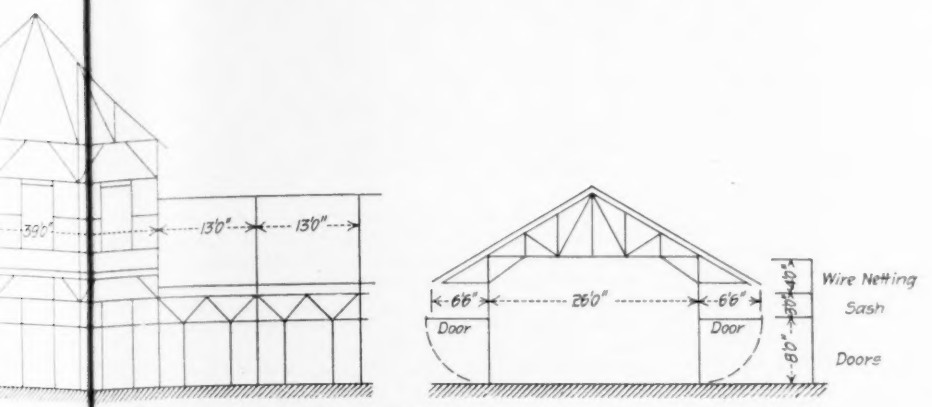


FIG. 6.—TRANSVERSE SECTION OF TWO-STORY FACTORY BUILDING.



9.—DIAGRAM ELEVATIONS OF FRAMEWORK FOR MARKET HOUSE FOR SOUTH AMERICA.

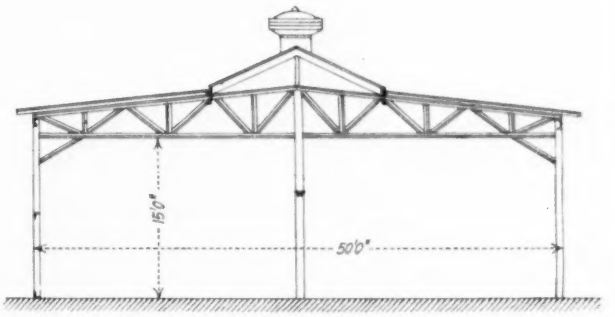
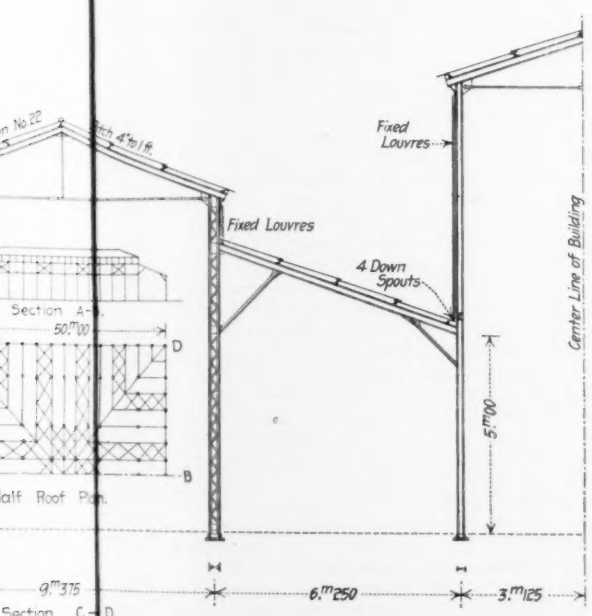


FIG. 7.—TRANSVERSE SECTION OF ONE-STORY STORE HOUSE.



RAM FRAMING PLANS FOR MARKET-HOUSE FOR BRAZIL.

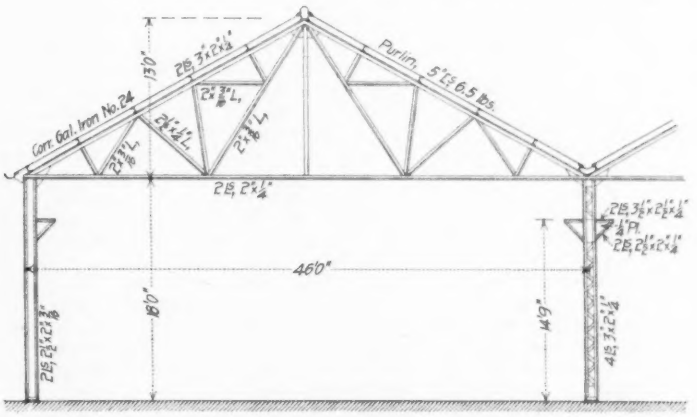
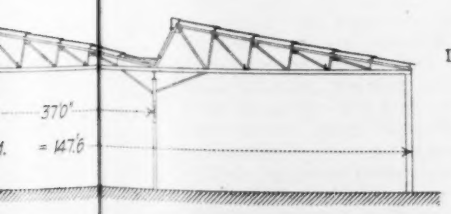
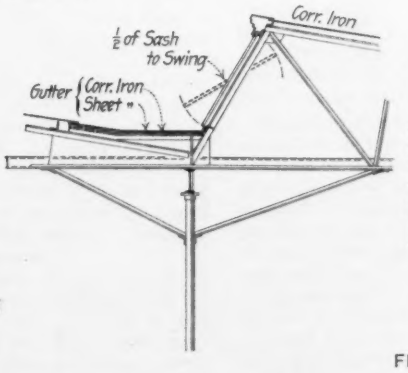


FIG. 10.—PART TRANSVERSE SECTION OF WORK-SHOP FOR SOUTH AFRICA.



OF TRUSS FOR MEXICO.



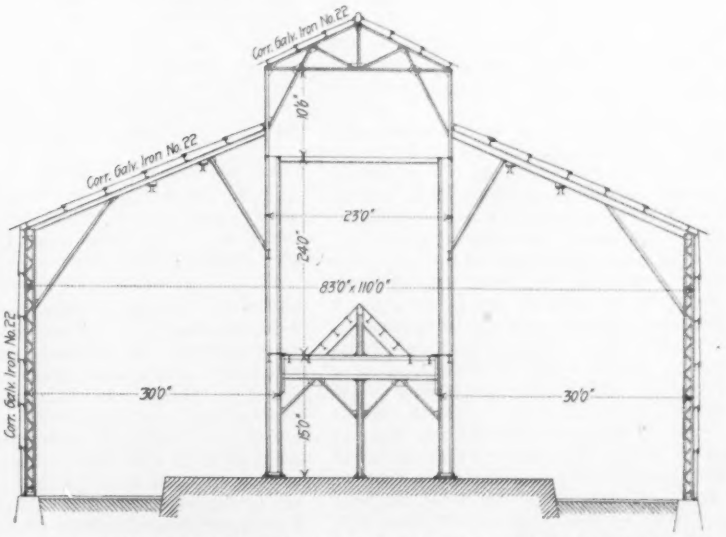


FIG. 11.—TRANSVERSE SECTION OF GOLD ORE MILL FOR SOUTH AFRICA.

UILDINGS FOR EXPORT.

l, Newton, Mass., Designer.

the board of trustees and in the public newspapers. No serious adverse criticism was ever made upon the plan, which, so far as your committee can now judge, would have solved all the troubles which then existed, and prevented the congestion which is now the subject of general complaint, to the extent at least of the capacity of the bridge to transport passengers.

Although no prohibition existed at the time against crossing Park Row, the plan adopted confined itself to the easterly side of that street, and could now be carried into effect without any additional legislation whatever, provided that it shall be adopted by the Commissioner of Bridges and approved by the Municipal Assembly. The "World" Building, however, has been erected upon a portion of the land which would have been required for the horseshoe loop recommended and approved for the termination of the bridge. The plans suggested, therefore, will have to be modified to the extent of transferring somewhat to the north and east the loop which was originally suggested. There would seem to be no serious difficulty in making the change, which will merely involve the condemnation of a larger space on the northerly side of the bridge. It is possible, moreover, that the passage of the elevated trains across the bridge, which was not then contemplated, and the trolley lines upon the carriageway might lead to some modification of the details of the original plan, but they would not be of a serious or difficult nature.

It may be of interest to review a little more in detail the history of the plans for improvement of the Brooklyn Bridge terminals: In 1887 and 1888, when the congestion of traffic at these terminals first made a change in them imperative, the bridge railway was operated as a separate, independent line. Cars were moved over it by cable and switched from the incoming to the outgoing tracks in the terminal stations at either end by small steam switching locomotives.

Under the system in use in 1888, three-car trains running at intervals of 90 seconds represented the utmost traffic capacity of the bridge. The problem was, therefore, how to more rapidly handle trains at the terminals so as to increase the traffic capacity.

In May, 1887, a plan was proposed by the late Chas. E. Emery for changing the method of switching at the terminals; it received approval by the Board of Trustees; Mr. Emery was appointed Consulting Engineer of the Bridge and authority was given to make the necessary changes. Shortly afterward, Mr. Emery's plan was criticised in detail in the columns of this journal. Following these criticisms the trustees withdrew their approval and in November, 1887, appointed a board of expert engineers to investigate and report to the trustees the best method of increasing the capacity of the bridge terminals.

This board of experts was made up of Messrs. Walter Katté, then Chief Engineer of the New York Central R. R.; the late Col. Julius W. Adams, Past President of the American Society of Civil Engineers, and Mr. Joseph Crawford, of the Pennsylvania R. R. A large number of plans was submitted to this board by various engineers, and it reported unqualifiedly in favor of the plans submitted by Mr. Wellington. It should be said here that Mr. Wellington's attention was first drawn to the problem by this work as an editor in criticising the earlier plans of Mr. Emery, and he later undertook to solve the problem himself.

Briefly described, what Mr. Wellington proposed was a loop terminal at each end of the bridge, so arranged that trains of almost any desired length, up to 14 or 18 cars even, could be run.

With an endless track at each end, switching was eliminated, together with all those chances of accident and delay which were especially likely to accompany it in the days when the switching was done by locomotives. Special arrangements were provided, enabling the trains to be loaded upon the curve, and many other excellent details were worked out in connection with the problem, which need not now be described.

With the unanimous report of the experts in favor of Mr. Wellington's plan, its adoption by the trustees appeared certain, especially as it was very favorably received by the public; but opposition soon developed from an unexpected source. The loop terminal, of course, required considerably more land than the switching systems, and the plans of the terminal, as shown by Mr. Wellington, included a part of the land on which the "World" Building now stands, as stated in the report above quoted. At that time the proprietors of the "World" had just purchased this site, and were about to begin the erection of their huge building. Naturally they were not anxious to have the land condemned for a railway terminal The "World," therefore, undertook a crusade against the Wellington plans, and this, coupled with the terms fixed by Mr. Wellington for the use of his plans, which he had meanwhile patented, served, we believe, to ultimately prevent their adoption. Some months later the terminal committee of the Board of Trustees presented a report in which Mr. Wellington's plans were condemned, chiefly on the ground of their great expense, and plans prepared by Mr. C. C. Martin, M. Am. Soc. C. E., for many years engineer in charge of the bridge, were adopted instead.

It is not our purpose to follow farther the many changes that have taken place in the Brooklyn Bridge during the 13 years that have passed since; but rather to address ourselves at once to the question whether the original plans of Mr. Wellington are still the best solution of the Brooklyn Bridge terminal problem, as the Chamber of Commerce Committee has reported.

It would be pleasant, indeed, to take this view of the matter and accept the compliment which the committee pays to our former talented associate. But candor, as well as regard for his reputation, compels the statement that his solution of the problem, however excellent it may have been for the conditions existing at the time of its presentation, is of very doubtful value for the conditions existing at the present day.

The whole plan of transportation over the bridge, as it existed in the mind of Mr. Wellington, and everyone else who studied the problem in 1888, was to keep the bridge railway a separate system. Every passenger who rode across the bridge in those days had to take the bridge cars at one terminal and leave them at the other. Since that time one of these changes of cars has been eliminated in large measure, for the Brooklyn surface cars and many of the elevated trains are now run clear across the bridge, landing their passengers at the New York terminal without change.

The very great advantage of this new plan of operation to the public which uses the bridge is apparent to everyone. A return to the old plan of an independent bridge railway with a change of cars at each terminal is out of the question. Because of this fact, however, Mr. Wellington's plan is no longer applicable. The central feature of his proposition was to increase the traffic capacity of the bridge by running trains of 14 to 18 cars in length. It need hardly be said that trains of such length are out of the question at the present day. Any change in the terminals which may now be made should be planned to still further facilitate the movement of through trains across the structure, and these trains must necessarily be of such lengths as are used on the Brooklyn elevated railways. Under these conditions, Mr. Wellington's loop system offers less traffic capacity than the present system. Mr. Wellington, in fact, only provided for trains at intervals of two minutes or more, whereas trains are now moved over the bridge in the rush hours at intervals of about 40 seconds.

Another important advantage which Mr. Wellington claimed for the loop plan was the elimination of switching locomotives; but these were abandoned long ago and switching by electricity was substituted. This feature of the loop plan has, therefore, no merit at the present day.

We might point out other features in which the conditions of the problem have radically changed during the 13 years since Mr. Wellington's plans were presented; but enough has been said to make it clear, we believe, that these plans are inapplicable at the present time. The question then returns, What plan should be adopted to relieve the congestion of traffic at the New York terminal of the bridge? It appears to us that the correct answer to this question is to be found not in the creation of a vast and elaborate terminal station at great expense, but in the elimination of the terminal to as great an extent as possible. The real trouble with the New York terminal of the bridge is that the passengers are all dumped at a point a quarter-mile short, more or less, of the places which they wish to reach. The real need is not for a vast terminal station at this point, but for a continuation of the railway lines on past the terminal toward the destination of the passengers. No one ever builds terminals for an ordinary city bridge. It simply forms a continuation of the streets which it connects on either side. So far as possible the present Brooklyn Bridge and further bridges spanning the East River should be treated in this way. The introduction of electricity as the motive power for both elevated and surface railways makes this possible now, as it was not when the present bridge was completed or when Mr. Wellington's plans were made.

At present all the Brooklyn surface cars which cross the bridge stop to discharge and take on passengers at the New York terminal upon four parallel loops. The crowding about these loop tracks in the rush hours is the worst feature of the present terminal station. The trouble arises from two causes. First, because passengers arrive faster than the cars can carry them away, and, second, because the streams of traffic are moving in different directions; those leaving the cars interfere with those entering; those waiting to take one line of cars are in the way of those who seek to take another. These four loop tracks, in fact, during the rush hours are covered with a dense struggling mass of human beings, whose behavior fully justifies the adjectives "indecent" and "dangerous" which the Chamber of Commerce Committee uses in its condemnation of the present terminal.

Suppose now, instead of trying to load and unload all these surface cars in the present limited space, that the present west bound surface car track on the bridge roadway were continued on down Park Row and Nassau St., while a returning track would be laid in William St. (the next parallel street on the east). At a point near William and Spruce Sts. an incline would lead the cars back onto the east bound bridge roadway. Connecting loops would join these two lines of track, say through Spruce St., through Beekman St., through John St., and through Maiden Lane, or even farther down town if that were deemed best.

The objection which will doubtless be made to this plan is that Nassau St. is too narrow to be obstructed by even a single-track street car line, and that to run the Brooklyn surface cars there would necessitate the erection of overhead trolley wires. To meet this suggestion it may be noted that by leaving one-fourth the cars to use the present loop tracks at the terminal and one-fourth to use the loop running down Spruce St., only half the cars which cross the bridge would have to use Nassau St. If it is still felt that a surface line in this street is impossible, it would be an easy matter to build the line as a single track subway, and this plan would have the added advantage of disposing of all objections to overhead wires. It may also be noted that these Nassau St. and William St. tracks need be used during only part of the day. For a considerable part of the 24 hours there would be little traffic to or from the downtown district and during this time the cars would naturally use the present loop tracks.

So simple a solution of the problems in connection with the tracks on the upper floors of the station is unfortunately not to be had. An extension of an elevated structure down Park Row or lower Broadway is hardly to be thought of.

Brooklyn dwellers who travel over the bridge on the elevated railways must continue to endure a break in their journey at the New York terminal; yet something can be done to help them and to materially relieve the present congestion of the station platforms at the same time. That something is so obvious that it is very likely already planned by the engineers who are working upon the problem. It is merely to extend tracks through the station and continue them out to a terminus directly over the station of the Rapid Transit road, which is to be located, we believe, near the corner of Center and Chambers Sts. At this new terminal station close connection would be made with Rapid Transit trains for both uptown and downtown; and a sufficient proportion of traffic would be drawn to this point to materially relieve the pressure upon the present terminal station. With such a second terminal station, working in harmony with the present terminal, it should be possible to load trains and dispatch them as close together as safe train movement

and regard for the strength of the bridge structure will permit. Such a train movement represents, of course, the ultimate traffic capacity of the present cable railway tracks. By the time that is attained, relief will doubtless be had through the completion of the second, third and fourth East River bridges, one after another, and perhaps by new tunnel routes as well.

LETTERS TO THE EDITOR.

Diagrams of Weights of Deck and Through Plate-Girder Highway Bridges.

Sir: With this I send you two diagrams giving the weights of both deck and through plate-girder highway bridges. The spans vary from 20 to 80 ft., and the width of roadway from 16 to 24 ft. The curves give the total weight of steel in the bridge, but do not include stringers or flooring. The main girders are proportioned for a uniform live load of 80 lbs. per sq. ft. over the entire floor, while the floor system is proportioned for a live load of 100 lbs. per sq. ft., or a 6-ton wagon. The unit stresses used for the main members are: Tension, 15,000 lbs. per sq. in; compression, 12,000 lbs. per sq. in., reduced by Gordon formula.

The deck bridges are provided with two main girders only, the stringers being placed crosswise, allowing the ends to cantilever. The through bridges are divided by floor beams into panels, the number of which is given on the diagram. They are not provided with sidewalk brackets. Weights in all cases, include shoe plates, and the necessary bracing. The weight of steel per square foot of floor surface is conveniently expressed by the following formulas:

$$\text{Deck girder bridges, weight per sq. ft.} = 2.1 + \frac{\text{span}}{5},$$

$$\text{Through bridges, weight per sq. ft.} = 3.0 + \frac{\text{span}}{4.25}.$$

Yours truly, H. G. Tyrrell.

Newton, Mass., Feb. 22, 1901.

The Effect of Low Temperature Upon Resilience.

Sir: In your issue of Jan. 31, under the heading "Impact Tests at Purdue University," Prof. W. K. Hatt in describing tests on a bar of steel which had been frozen for the middle third of its length, says:

> The frozen length had thus been converted to a harder and more elastic steel which transferred the energy of the blow to the softer and warmer parts. Of course the total resilience of this partly frozen bar is less than that of the wholly warm bar. If this one bar may be taken as an index of what happens in general and what has happened in three or four cases in the writer's experience, we may believe that a locomotive connecting-rod is stronger to resist the shocks of ordinary service in winter than it is in summer. But, of course, in case the necessity arose to take up unusual and undesigned for shocks, the rod will break more easily in winter.

Since a connecting-rod should not fail under shocks it is designed to safely endure, Professor Hatt's statement seems to lack clearness. The statement reads in effect, that a connecting-rod is weaker in summer, but will fail more easily in winter.

It seems to me that Professor Hatt has entirely missed the conclusion to be drawn from the peculiar behavior of these partly frozen test-pieces. It must, of course, be admitted that the chances are against any significance whatever attaching to these few peculiar cases; but if we assume that they do possess significance and are not merely accidental, then, as Professor Hatt suggests, the breaking outside of the frozen part must indicate that the steel is converted into a harder and more elastic steel by freezing. This, however, at once throws doubt upon the reliability of Professor Hatt's temperature tests which show low resilience for the frozen specimens.

These temperature tests were made by enclosing the 8-in. test-pieces in a tube of freezing-mixture during the test. This must of necessity produce varying temperatures in the piece, being lowest at the middle, and higher at the ends. Such a test-piece in which the middle is of harder and more elastic steel cannot be compared directly with a test-piece of uniform temperature throughout.

I would suggest that temperature comparisons can hardly be successfully made upon 8-in. test-pieces, and that the test-piece with sharp neck as used by Mr. Russell is the proper form for such an investigation.

Very sincerely, Daniel B. Luten.

Los Angeles, Cal., March 3, 1901.

(Proof of the above letter was submitted to Prof. Hatt, and we append his reply as follows:—Ed.)

Sir: I respond with pleasure to your invitation to explain more fully my views concerning the effect of low temperatures (say below 0° F.) on the resistance of steel to impact.

Your correspondent's difficulty lies in his failure to distinguish between (1) elastic resilience, i. e. that within the elastic limit, and (2) total resilience, i. e. that up to rupture.

(1) The effect of low temperature is to elevate the elastic limit of steel,* and therefore to increase the elastic resilience. We may thus believe that if a connecting rod will absorb the ordinary shocks of service in summer, without exceeding the elastic limit, there will be a greater margin of safety in winter.

(2) The effect of low temperature is, however, to decrease the ultimate resilience of steel.† In case of accident, the necessity arises to absorb a shock measured by an amount of energy greatly in excess of the elastic resilience. Thus, in case of accident, this connecting rod, with decreased total resilience, will rupture more easily in winter than in summer.

The writer will not attempt in this place to carry on a discussion of the methods and results of his experiments.

Yours very truly, Wm. Kendrick Hatt.

Purdue University, April 3, 1901.

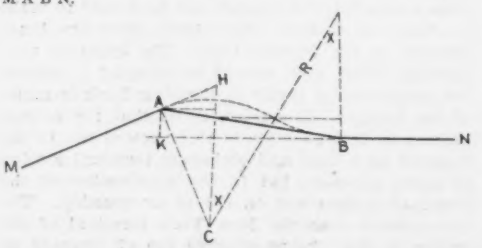
*See Johnson's "Materials of Construction," p. 560, and "Report of French Commission," vol. 2, p. 330.

†See Johnson's "Materials of Construction," p. 567; Kent's "Pocket-Book," p. 384; Engineering News, Jan. 31, 1901; Report of French Commission, vol. 2, p. 325 et seq.

A Problem in Railway Location.

Sir: I send you herewith a solution of a problem in location, effected by an analysis that is novel, so far as I am aware.

Problem: Required to find the common radius of a reverse curve to unite the points A and B of the line M A B N.



Let the distance A B be given; H A B = A; A B K = B; A C H = C = A − B.

Then

$$A K = (2 \text{ vers } X - \text{vers } C) R;$$

$$\text{and } B K = (2 \sin X + \sin C) R.$$

For sin C, write a; for vers. C, write c; for tang B write b.

Then

$$\frac{A K}{B K} = \frac{2 \text{ vers } X - c}{2 \sin X + a} = b;$$

or,

$$b \sin X + \frac{a b + c}{2} = \text{vers. } X. \quad (1)$$

Sin X and vers X are both unknown. If we may suitably express vers X in terms of sin X, we can solve this equation.

$$\text{Vers. } X = 1 - \cos X.$$

$$\text{Cos } X = \sqrt{1 - \overline{\sin X.}^2}$$

$$\text{Vers } X = 1 - \sqrt{1 - \overline{\sin X.}^2} \quad (2)$$

Substituting in (1)

$$b \sin X + \frac{a b + c}{2} = 1 - \sqrt{1 - \overline{\sin X.}^2}$$

We have here an equation of the second degree, with sin X as the unknown quantity.

Find X. Then

$$R = \frac{A K}{2 \text{ vers } X - \text{vers } C} = \frac{B K}{2 \sin X + \sin C}.$$

Edwin E. Woodman.

St. Paul, Minn., March 23, 1901.

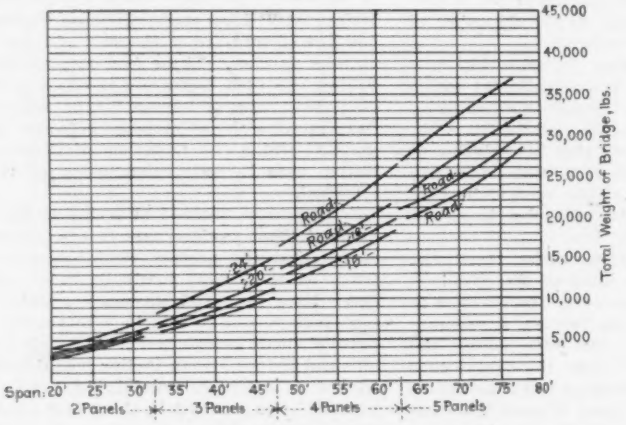
The Economic Value of Paved Roads.

Sir: I have noted with interest the appearance in the arena of a champion of earth highways. For years no one has come forward to take the part of the much maligned "dirt road," as against macadam, and it is refreshing to hear the other side so well presented by Prof. I. O. Baker in his recent criticism of the U. S. Department of Agriculture (Eng. News, Nov. 15, 1900). I observe with regret, however, that since Professor Baker has found certain errors in the statistics given out by that department, he is swinging to the extreme in argument, and now goes so far as to say that macadam roads are a luxury and are not an economic necessity. With this conclusion of his I take issue, and shall give some reasons for my difference of opinion.

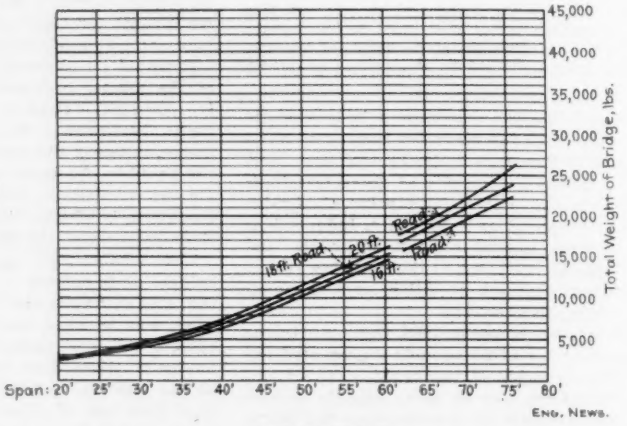
Professor Baker's first argument, and the strongest one, is that a farmer's team is ordinarily idle part of the year, and if used for hauling during such idle period, little or nothing can be rightly charged for its services. In his answer to Professor Baker's criticism, Mr. Dodge, of the U. S. Department of Agriculture, seems not to have observed that this statement of Professor Baker's must be successfully controverted, or shown not to be generally applicable, if he hopes to maintain the proposition that macadam roads are an economic necessity.

While it cannot be denied that in certain classes of farming more teams are needed to till and harvest crops than to haul them to market, and while it is evident that in such cases less should be charged against horse hire when hauling, I think it can be shown that Professor Baker has underestimated the cost of hauling to even a greater extent than Mr. Dodge has overestimated it.

In the first place what authority has Professor Baker for believing that most of the produce is hauled during the idle period of the year? He has evidently had in mind the raising of grain and other products that may be stored indefinitely, and he thinks that no other produce is worthy of consideration, for quoting the census report he says: "Dairymen, gardeners, vinegrowers, florists and nurserymen constitute only 1-57 of the so-called farming class." Granted. Does that prove that the weight or the value of the fruit and other perishable crops is only 2% of the total farm output? No, for in the first place while 2% of the farmers are engaged in the production of fruits, etc., exclusively, it is undeniable that almost every farmer in this country raises a considerable amount of fruit and



THROUGH BRIDGES.



DECK BRIDGES.

DIAGRAMS SHOWING WEIGHTS OF THROUGH AND DECK PLATE GIRDER HIGHWAY BRIDGES, WITH SPANS FROM 20 FT. TO 80 FT.

garden truck, and to such an extent is this true that it may be safely said that within a radius of 30 miles of every city all farmers are producers of these perishable products, if not exclusively, certainly to a large extent.

Professor Baker will not deny that the fruits, garden truck and dairy products must be delivered without delay to the markets or storage plants, that therefore farmers must employ teams for the special purpose of hauling such products, and wherever such products are produced the cost of hauling by team is not merely nominal. The weight of these products is less, it is true, than that of grain, etc., but the fact must never be lost sight of that the element of value is quite as important as the element of weight. It is well known that at certain periods of the year teams cannot be hired for love or money, since every farmer is diligently engaged in getting his products to market. There are times in fact when thousands of dollars worth of produce rots through inability to get it to the storage plants. During such periods the economic value of macadam roads is so many times in excess of any ordinary estimate that it is difficult to fix a limit thereto.

I take it that Professor Baker has erred not only in his interpretation of statistics, but that he is also in error when he says that a macadam road is little if any better than the best earth road for hauling purposes. If he means by the best earth road, a first-class gravel road in summer, I agree with him, but such gravel roads are so rare that I cannot believe it was his intent to refer to them. As an engineering contractor I have had occasion to note the weight of loads hauled over various roads, and my observations accord closely with the authorities who have investigated the matter by means of dynamometers. I have found that a team can haul three tons over a 6-in. macadam road with the same ease that it can haul 1½ tons over a "dirt road" in summer; while in rainy weather the load on an earth road drops to as low as three-quarters of a ton, the macadam being unaffected. In this matter I feel that Professor Baker is entirely in error, and that his championship of earth roads has led him to assume the position of an advocate rather than a judge.

There is an advantage of a macadam road that has not been mentioned by writers at all, so far as I know, namely, that on a macadam road a team loaded with one ton can trot half as far again in a day as it can walk with the same load on an earth road.

Now this has an economic value hitherto not dwelt upon by hard-road advocates, for it is obvious that where with earth roads a circle with a radius of 10 miles constitutes the area within which the farmer may go to market and return in the same day, with stone roads the radius becomes 15 miles, and the area tributary to the market center is doubled. The effect is obvious. More farmers are able to haul perishable products daily to market with consequent reduction in the price of such products. Perhaps it is this latter consideration that has made good-road advocates shy of using such an argument for fear that the farmers would rise in their wrath and smite them for suggesting lower prices.

But the farmer should bear in mind that if he lives in a district which by road improvement is enabled to send more produce to market and sell cheaper than other similar districts without road improvement, he will enjoy the direct benefit of always finding a ready market for his produce which will be shipped to other parts of the state, and will in all probability find creamery, cold-storage, canning and evaporating plants springing up ready to receive his produce where none existed before.

Enough stress has not been laid upon the economic advantages of macadam roads in wet weather. I have lived in farming communities where eggs, fruits, etc., could not be hauled to market at all during rainy spells, with inevitable loss both to the farmers, who, when they finally did get to market, found a glut of materials and consequent depreciation in prices, and a direct loss to the consumer who during the temporary famine had to pay famine prices.

Passing now to consideration of the cost of hauling less perishable products, which undoubtedly form the greater part of farm tonnage, we may concede that if hauled during an otherwise idle season the cost of haulage is less per ton mile than for the more perishable products. The question is, how much less this cost is. Professor Baker says 50% to 70% less, and cites in support of his contention a few isolated instances where hauling has been done for 6 cts. a ton mile as compared with the ordinary charge of 20 cts. or 25 cts. a ton mile made by freighters. He goes even farther, stating that the hauling often costs practically nothing, since the team unless so engaged would be idle. What justification is there for charging all the cost of team maintenance to cultivating and harvesting the crop, while regarding the time occupied in hauling as practically valueless? If a team is occupied on a farm 150 days in the year, and is then engaged 50 days in hauling to market, it is obvious that the total yearly cost of maintenance should be divided by the total days worked (200) to obtain the team cost per day worked. Professor Baker under such conditions would divide by 150, calling the 50 days spent in hauling as so much rescued from idleness and therefore clear gain. One is tempted to ask why it would not be equally fair to divide by 50 to obtain the cost of team item in farming and regard the 150 days spent in tilling as the portion saved from idleness. Furthermore Professor Baker seems to have in mind only such small farmers as do all their own work and therefore do not pay out any wages for teamster hire, which is far from being the ordinary condition of affairs throughout the country. Before going further into this problem of hauling farm produce it will be necessary to determine the average cost of team maintenance and driver's wages. For this purpose I have referred to my own expense accounts and find that the monthly cost of maintaining a team has been ordinarily as follows:

½ ton hay at $10	$5.00
30 bu. oats, at 35 cts.	10.50
Straw for bedding	1.00
Shoeing and medicine	2.00
Total	$18.50

This is equivalent to $222 a year for team maintenance, to which add $60 a year for interest and depreciation of team, harness and wagon. There are about 300 working days in a year, but of these at least 100 days are necessarily spent in idleness on account of bad winter weather in northern climates, leaving 200 days of the working season available. The wages of a driver are seldom less than one dollar a day and board, or $1.25 cash, which is equivalent to $250 a year paid out for wages of driver, to which must be added not less than $30 for wages of hostler attending each of a number of teams during winter months. In view of the fact that a farmer is frequently his own hostler we shall omit that item, but we still have left a total of $532 for team maintenance and driver's wages to be divided by the number of days out of the 200 actually worked.

My own experience has been that at least 10% of these 200 days are lost on account of rainy weather, leaving a net total of 180 days worked. This makes the actual cost of team maintenance and driver's wages but slightly less than $3.00 per day worked, which is in fact the ordinary price paid by contractors for hire of farmers' teams and drivers, even during a dull season

Since 1½ tons hauled 10 miles, the return trip being made empty, constitutes a good day's work over a hard-earth road, it follows that the cost per ton mile is 20 cts., when wages of team and driver are $3.00 per day. This is a low price, for with bad roads the load rapidly decreases and the cost rises to 40 cts. per ton mile. If the farmer hires his driver it is certain that even were the team time valueless he would still have to pay not less than 10 cts. per ton mile for the wages of the driver where earth roads are used.

Assuming that upon the construction of a paved road half of his teams would be lying idle in the barn (and this is granting more than Prof. Baker has proved), the cost of hauling rightly chargeable to the team would still be not less than 5 cts. per ton mile on earth roads, which added to the 10 cts. per ton mile for a driver's wages, makes a total of 15 cts. per ton mile for hauling non-perishable farm produce where paved roads would leave in idleness half the teams. This is the least that I will concede that it costs to haul heavy or bulky non-perishable products, taken as an average throughout the Northern states, while 20 cts. a ton mile is a minimum for hauling perishable products over earth roads. A paved road will enable the farmer to reduce this cost in either case by at least one-half.

It will help us to a more clear understanding of the problem if we take some simple example and solve it as follows:

On a 160-acre farm, 200 tons will ordinarily be hauled annually to market, and if the haul is three miles, three trips may be made daily with one to one and a half tons, requiring 44 to 67 days annually. Assuming 55 days as an average, the cost of hauling non-perishable products would be $165 annually, half of which, or more than $80, could be saved by the building of hard roads. If the farms were square there would be four such farms fronting on the highway per mile and the annual saving would be $320 for each mile of road, which does not take into consideration farms not fronting directly upon the highway, nor the hauling of dairy and other products for which trips must be made daily with light loads.

This sum, however, is sufficient to pay the interest upon first cost, and to maintain an excellent paved road, where the average haul is 3 miles, the advantage increasing with greater hauls. I shall now briefly touch upon certain other factors in this economic problem, factors that are of great importance, though not reduceable to a dollars and cents standard. There is unquestionably a limited distance of haul beyond which it will require extra teams to do the hauling beside keeping busy the regular farm teams, and it is undeniable that this limiting distance will be much greater where stone roads are used.

Is not the farmer who resides beyond the limiting distance where earth roads are used greatly the gainer when he is brought within the limiting distance by the building of stone roads?

The answer must necessarily be in the affirmative. It is repeatedly stated that upon the stone roads in Europe produce is hauled more than 50 miles to market. Where is this done in America over earth roads? Answer may be made that our rail service is far better, but even granting the truth of this statement, the argument is not vitiated. The farmer is always the gainer if he has more than one market to which he may go, and a market that he may attend in person. It must never be forgotten that the handling and carting from railway stations to market in a city would suffice to pay for many miles of haul over good roads; it must be remembered that railway freights per ton mile are far greater on short than on long hauls; it must be remembered that many railway companies will not sidetrack a car for less than $5; it must be remembered that a farmer usually does not have a whole car load, yet will have to pay full car rates; it must be remembered that car famines are frequent; and, finally, it must be remembered that after shipping by rail the farmer must often go personally to the market to dispose of his produce or be fleeced by the local middle man.

If he who so glibly writes of the few mills per ton mile it costs to haul by rail were merely to talk with an intelligent farmer he would quickly ascertain some of the reasons why he can better afford to haul many miles over a good road to market, than to haul a short distance to the station and the rest by rail.

Inability to profitably raise certain crops for which the soil is especially adapted is more frequently due to the cost of hauling over poor roads than is commonly supposed.

At a recent session of the N. Y. State Railway Commissioners I heard a number of intelligent farmers testify that a few miles haul over earth roads to the station absolutely prevented them from raising sugar beets for which the soil was especially adapted, and in which there was subsequently a great profit upon the building of a trolley road near their farms. The very act of building improved ways for transportation starts the cultivation of more profitable crops, and the community first to appreciate this fact and act upon it is the one to enrich itself fastest.

I could from my own experience give instances similar to the one just quoted, but having already written at greater length than at first intended, shall not go into the matter of personal experience that is but a repetition of universal experience wherever paved roads have been built.

I have thus far conceded Prof. Baker's assumption that non-perishable crops may usually be hauled at leisure and consequently at less expense; but I shall now show that as a matter of fact the cereals only should be classed as products that may be hauled during the "idle period," and they not always. Professor Baker has apparently given little or no thought to the weight of different crops produced per acre of land; but an intelligent discussion of road economics is impossible without such data.

The following gives a rough approximation of the weight per acre of what I have termed the non-perishable crops, the soil being well tilled and fertile:

	Tons per acre.		Tons per acre.
Wheat	1	Sugar beets	18
Corn	2	Turnips	20
Potatoes	8	Cabbage	25
Carrots	15	Apples	20

It is quite obvious that, a farmer possessing 100 acres of wheat and therefore 100 tons can haul it 3 miles over good earth roads with one team in about 25 days; but if he had the same acreage of potatoes it would require 8 teams to market it in the same time or one team would be kept busy 200 days; while to market a 100-acre crop of sugar beets would require one team 450 days—a year and a half, or 18 teams working steadily for a month.

It is now clear why the farmers above referred to were unable to raise sugar beets profitably until a railroad was built nearer their farms; yet a first-class macadam road virtually shortens the distance to market by one-half at the least estimate, and more frequently by much more. That the potato crop, for example, is not insignificant compared with wheat is evident when it is stated that for every 100 bu. of wheat 40 bu. of potatoes are raised in the U. S. Other interesting and valuable data could be given to contradict Professor Baker's gratuitous assumption that as a rule farm-team time at the hauling period is comparatively valueless.

Upon the building of paved roads, butchers from the nearest market are enabled to supply farmers with fresh meat daily and do; and at the same time their delivery wagons gather up eggs, butter, etc., thus saving the farmer many trips to market. Free rural delivery of mail will follow the construction of paved roads, since the speed that a mail carrier can make is thereby doubled and may be increased many times more by the use of automobiles. Motor vehicles will assuredly displace horses wherever pavements are good and the virtual distance to market will thereby be reduced.. Free delivery is an economic advantage in that it keeps the farmer in daily touch with the market. The building of paved roads is always followed by the building of country homes by city men, with consequent rise in land values.

And speaking of a rise in land values about which there is not the slightest doubt, it may be well to state that such a rise is the true index of all the economical advantages derived from building good roads. In one township that I know of the rise has been $9 an acre due to the construction of good roads and the "$9 an acre" means an average of all farms in the township; those nearest the roads, of course, securing the greatest rise.

While the U. S. Department of Agriculture may have erred in some of its deductions from comparatively meager statistics, it is self-evident that Professor Baker is far more in error, for his reasoning is based on still more meager data. While one can appreciate his honest en-

deavor to ascertain the truth, one can not but regret his resultant enthusiasm in endeavoring to destroy the effect of all that has been said in favor of good roads as an economic necessity.

Were he alone in his championship of earth roads there would be little to fear and much to be gained, for criticism is always a healthy tonic, but there is a tendency on the part of some technical periodicals to side with Professor Baker, a tendency that would delay the good-roads movement were it to become more than a tendency. No one argues in favor of paving every country road as being economically desirable; but I maintain that there is not a main traveled road in a well-settled farming community where gravel or stone exists that can not be profitably paved, if not 16 ft. wide then 8 ft.; if not 6 ins. deep then 4; if not with stone then with gravel.

Yours truly, Halbert Powers Gillette.

Rochester, N. Y., March 22, 1901.

(Since this journal has taken substantially the same position as Prof. Baker with regard to the economic value of macadam roads in farming districts, we undertake to reply to a few of the points raised in the preceding letter.

In the first place, it is apparent from our correspondent's letter that he quite misunderstands the position taken by this journal and by Prof. Baker. We are not opposed to macadam road construction whenever and wherever the people who use the roads are willing to tax themselves to pay for such roads. What we do oppose is the false economics that would have farming communities burden themselves with a load of debt to build good roads, in the belief that these good roads are going to directly save money enough to repay their cost. We hold that this has not yet been so proved as to justify any such course, and that the farmers themselves are better judges as to whether good roads will pay them than the Good Roads advocates who seek to instruct them.

Again, our correspondent, when his letter is closely analyzed, is really talking chiefly not about farmers, as that term is commonly understood, but about market gardeners. We do not question at all that in the vicinity of cities and large towns, radiating out to a greater or less distance, according to the size of the population to be served, it will pay to build hard roads, over which market gardeners, milkmen, poultrymen, florists and other similar producers can carry their wares to market without the intervention of the railway or the express company or the middleman. The building of such roads will also serve a large pleasure traffic, will tend to build up suburban districts, increase the value of lands and prove beneficial in many other ways.

As a matter of fact, we presume that 99% of the macadamized roads thus far built in the United States outside of city streets have been built in just such locations. The great big error of the Goods Roads boomers which we have endeavored to expose is that exactly the same thing can be done in purely farming regions in all parts of the United States with equally beneficial results.

In the second place, let us set it down again that the first question to settle in deciding whether it will pay to macadamize a road or not, is the volume of traffic. Our correspondent writes from a thickly settled and wealthy section of Western New York, and he has large ideas as to the volume of traffic on country roads, as his estimate of the average annual marketed product of a 160-acre farm at 200 tons makes evident. But this is far from being the typical farming section of the United States. We must consider the vast tracts of light sandy soil and of mountain land in the South, the thinly settled regions of the West, the great proportion of waste lands in the Eastern States. Where each and every acre can yield such crops as our correspondent estimates, and a market can be found for them, traffic enough may very likely be found to warrant extensive hard road building. There are very small areas of the United States, however, where a large proportion of the surface is not waste land. Forest, swamps, and barren hillsides, stretches of sand or rock account for a large part of the area of most farming regions and greatly reduce the producing capacity of a given area. Many sections, too, are so remote from markets that only a few crops can be profitably raised. Now it is this typical farming region of which we speak when we allude to the economic fallacies of the good roads movement, and not of the suburban market gardens, the Michigan sugar beet farms, or other places where sufficient traffic can be shown to justify radical road improvement work.

We shall not take space to discuss Mr. Gillette's computations as to what it costs the farmer to haul his products to market in the idle season, nor his estimate of the gains he can make in increased prices. We have an idea that the farmer knows better than any of his advisers whether he could keep fewer horses or hire fewer men if he had better roads on which to haul his products to market, and as to how much he loses by inability to send them at a given time. What we maintain is that these are matters which the farming communities are better competent to settle for themselves than any one else is to settle it for them. When and where good roads will pay the farmers, they are pretty sure to be built; and where they will not pay, and cannot well be afforded as a comfort or a luxury, they are not likely to be, notwithstanding the efforts of good roads advocates.—Ed.)

Notes and Queries.

Mr. N. A. Tenney, West Alexander, Pa., writes that Mr. P. L. Wise's letter in Engineering News of March 14, enabled him to quickly repair a couple of broken steel tapes when located a long way from a repair shop. He says:

For rivets we used small wire nails; those from cigar boxes do nicely, if you cannot get large pins. We got some corset steel from the ladies in the house, cut it to the right width with a pair of sheep shears, and in a short time the tapes were ready for use.

K.—Dunkirk, N. Y., writes:

Can you or any of your subscribers give me a brief description of how chains are made at the present time? Is there any method of making ordinary link chains other than welding one link at a time?

We find the following item, which may answer our correspondent's query, in London "Engineering" of March 15:

At Lemington on the Tyne, just beyond the Scotswood Railway Bridge, large works have been erected for rolling chain cables direct from steel bars. The bars are heated in a furnace 70 ft. long, and are drawn direct into the rolls. In the course of its passage a bar of this length, weighing nearly 2 tons, is rapidly converted into a red-hot 1¾-in. cable 90 ft. long, link within link without weld, and with the stud already in its place in each link. The links are connected by webs and fins, which are afterwards removed cold by punching and special planing machines. It is claimed that a cable made in this manner from the usual ship quality of steel is 50% stronger than the best welded iron cable of the same size, and that it is also very tough. The works have a frontage to the river of 1,000 yds., and are equipped with powerful machinery. The rolling-mill engines have 48-in. cylinders, and drive a mill weighing over 250 tons. There are punching machines for removing the fins from the links, and a special planing machine for cutting the inner connections. The principal machines have been specially designed for this work, and patented in many countries. Rolls are now being prepared for other sizes of cables, and eventually heavy short link crane and hauling chains will be proceeded with by the Rolled Weldless Chain Co., Limited, of Newcastle-on-Tyne.

THE WHITE STAR STEAMSHIP "CELTIC" was launched from the Belfast yard of Harland & Wolff on April 4. The "Celtic" is the largest steamship afloat in the world. She is 680.9 ft. long; 75 ft. beam; depth of hold, 44.1 ft.; gross tonnage, 20,880; net tonnage, 13,650; displacement, 33,000 tons. This vessel has nine decks; will carry a crew of 335 men and accommodate 2,859 passengers of all classes. Her tonnage exceeds that of the "Oceanic" by 3,600 tons; and is nearly double that of the "Kaiser Wilhelm der Grosse." The "Celtic" is not built for speed, but is primarily a cargo and passenger carrier. In comparison, the gross tonnage of the "Great Eastern" was 22,500 tons; her length between perpendiculars was 680 ft., and 691 ft. on deck; her extreme beam was 83 ft., and depth of side 58 ft., with 30 ft. draft, loaded. At 30-ft. draft the displacement of the "Great Eastern" was 27,000 tons, or less than that of the "Celtic."

AN EXHIBITION OF AUTOMOBILES was held at the Coliseum, Chicago, March 24 to 30, and comprised a number of vehicles propelled by steam, oil and electricity. While many of these were exhibited by companies having their vehicles in actual use, it was noticeable that very little was said about the mechanism, the representatives of the various makers appearing to think that visitors would be much more interested in the general appearance and the claims for speed and endurance than in the character of the machinery. Besides the usual styles of four-wheel cabs, carriages, delivery wagons, etc., there were some three-wheeled carriages and quite a number of two-wheel and three-wheel motor cycles. There were no important novelties, but the exhibition served to show the practical development of this new industry.

THE EIGHT-TRACK BASCULE BRIDGE of the Scherzer rolling-lift type over the Chicago Drainage Canal was tested recently by the officials of the Pennsylvania Lines, with a moving load of 6,500 lbs. per lin. ft., and the bridge showed a central deflection of only ⅝-in. The bridge was described and illustrated in our issue of May 24, 1900.

THE PUBLIC IMPROVEMENTS OF NEW YORK, already planned and at least nominally provided for, contemplate the expenditure of about $200,000,000 in the near future. Some of the larger items in this list are as follows: Authorized river-front improvements, $40,000,000; rapid-transit tunnel, in progress, $35,000,000; Brooklyn and Staten Island tunnels, under consideration, $30,000,000; Second East River bridge, under construction, $12,000,000; Blackwell's Island or fourth East River bridge, commenced, $10,000,000; Third East River bridge, authorized, $15,000,000; Blackwell's Island Park, talked about, $4,000,000. The Jerome Park reservoir, street widening, public buildings, etc., already authorized and in part constructed, make up an enormous but indefinite aggregate.

THE TOTAL MILEAGE OF STREETS IN GREATER New York on Dec. 31, 1900, according to the last report of the Department of Highways, was 2,520. Of these all but 767 miles were paved. The classification of the several kinds of pavement is as follows: Specification granite, 327 miles; square granite, 7; specification trap, 47; Belgian trap, 77; sheet asphalt, 253; block asphalt, 11; cobble, 229; macadam, 766; brick, 20; gravel, 14. Fractions have been omitted above, including 0.08-mile of karri wood, which is the only wood pavement in the city. The 767 miles of unpaved streets are divided between the different boroughs as follows: Manhattan, 33 miles; Bronx, 199; Brooklyn, 162; Queens, 267; Richmond, 106. Mr. Jas. P. Keating is commissioner of highways and Mr. Andrew E. Foye is acting chief engineer.

CENTRAL TROLLEY POLES at Indianapolis, Ind., have had to be removed on the streets upon which the interurban lines of the Indianapolis Street Ry. enter the city, on account of the size of the new cars for the interurban service, which would not pass the poles. Side poles with span wires to carry the trolley wires have been substituted.

A STREET RAILWAY CONGRESS will be held in London, England, in July, 1902, under the auspices of the International Tramways Union (whose headquarters are at Brussels, Belgium), and the Tramways & Light Railways Association, of England. This will be the biennial congress of the Union, whose last meeting was at Paris in 1900 (Eng. News, Nov. 15, 1900), and the following is the list of subjects of the reports to be presented: 1, Transfers; 2, Gage of track; 3, The determination of the power of generators, motors, etc.; 4, Brakes; 5, Payments for franchises; 6, Relations of street railway companies to the streets occupied; 7, Location of car sheds in relation to the general plan of the lines; 8, Systems of traction; 9, Relation between the number of passengers and number of seats available; 10, Central power plants; 11, Underground railways; 12, Car heating; 13, Cost of electric current generated by steam, gas or water power plants; 14, Mail, baggage, freight and express traffic; 15, Fare registers and ticket registers. Mr. L. Janssen is President, and Mr. F. Nonnenberg is Secretary of the International Tramways Union.

THE GENEVA-CHAMOUNI ELECTRIC RAILWAY will be open to travel about July 1, 1901. This line has been constructed at great cost by the Paris, Lyons & Mediterranean Railway Co.; commencing at Fayet-St. Gervais, a station on the line of that railway two hours by rail from Geneva. The electric line running from this station to Chamouni is 12½ miles long, double-track, 1-meter gage. For 2¼ miles a rack railway is used to overcome grades, the steepest of which is about 1 in 10. It is proposed to run six trains daily from Geneva to Chamouni, making the trip in from 3½ to 4 hours, according to train; the second-class fare from Fayet-St. Gervais to Chamouni will be 38 cts., and the first-class fare is not yet announced.

AN ELECTRIC RAILWAY is to be built from Milan, Italy, to Gallarate, about 25 miles, and then branch to Lake Majore, Lugano and Varese, abutting on the towns of Arona, Lavens and Porto Ceresio. The lengths of the branches are 16.12, 19.22 and 20.46 miles respectively, the aggregate length of line being nearly 81 miles. The third-rail system is to be employed, and 20 motor carriages and 20 trailers will make up the equipment. The motor carriages will each carry 75 passengers, 63 seated; the trailers will carry 90 passengers, with 63 seated.

COMPOUND LOCOMOTIVES formed about 35% of the total output of the Baldwin Locomotive Works in 1900. This total output, however, includes switching engines, compressed air and electric engines, mine locomotives and locomotives exported to foreign countries. Of the road locomotives built by the works in 1900 for American railways, nearly 70% are said to have been compounds.

LARGER FREIGHT CARS FOR GERMAN RAILWAYS are being experimented with in the interest of Rhenish mine operators. The new cars have three instead of two trucks, and will carry 25 tons instead of 15 tons. A former experiment with 4-truck cars failed owing to the large increase of dead load. It has already been demonstrated that the wear of the track is less with the larger than with the ordinary car, owing to a better distribution of the load.

COMBINED TROLLEY AND CONDUIT ELECTRIC RAILWAY SYSTEMS.*

By A. N. Connett.

In many cities where the overhead trolley is or will be admitted on surface tramways, there often exists a street or a central zone where it is or will be expressly prohibited. Again, other cities prohibit absolutely the trolley within their limits, but penetrating lines from the suburbs come to the limits with the trolley, and from there a change of cars must be made to enter the city, or the cars must be equipped so as to be able to use another system of traction. The general engineering problem in these two cases is about the same. Broadly speaking, it is that the electric motors with which the car is equipped must be furnished with current from a source other than the overhead wire along a part of its route. There is no one well-defined system or method of solving the difficulty upon which engineers are agreed as being the best. It is naturally that this should be so, local conditions being such an important factor that each individual case must be carefully studied by itself, so that what would be a correct solution in one place might not be justified in another. The three means of solving the problems are by: (1) Accumulators, (2) surface contact, (3) open-slot conduit.

It is not the purpose of the author to discuss the first two systems. As the result of his experience with accumulators he would advise that if in a given case their installation should seem to be advisable, the contract should be drawn in the form of a rental for the batteries on the terms of paying a fixed sum per automobile car-mile for their use; this sum should include the entire cost of maintenance and renewal of the batteries for a fixed period. Penalties should be inserted in the agreement for each trip lost due to failure in working of the batteries; and their electrical efficiency should be guaranteed up to a certain standard, below which the excess waste of energy should be paid for at an agreed rate per ampere-hour. This method has been employed in France and in Germany with good results. It seems the best devised to protect the user from a poor form of battery for a given work, and at the same time to insure the upkeep of the batteries in the best possible conditions; this last is to the evident advantage of both buyer and seller. The batteries should be placed under the car-body if possible; if this is not done, the acid fumes are disagreeable to passengers, and the effect will be a diminution of receipts and numerous complaints.

If a surface-contact system should be decided upon, the choice of one of the many systems will require careful study. If the number of cars using the portion of track to be equipped with this system is large, and the comparative length of such portion of track is small, it will be found that the cost of the car-equipments for a system where the cars carry the magnets is relatively excessive, and that a system employing a magnetic switch for each contact-point will be much cheaper. With the condition of a relatively great importance to the surface-contact portion of a line, this conclusion as to first cost might easily be reversed. The vital questions of working, maintenance, and safety, have to be given the most careful consideration, with the disadvantage that there is at present very little to be learned from experience on actual working lines, which are either too few or too recently installed.

There should be no hesitation about adopting the conduit, where financial and constructional conditions make it possible, for this system has proved itself to be workable. It has passed entirely beyond the experimental and uncertain period, and can now be adopted without hesitation as an electric tramway system for the propulsion of cars. It can fail completely, but even partial failure will be the fault either of design or of construction, or of both.

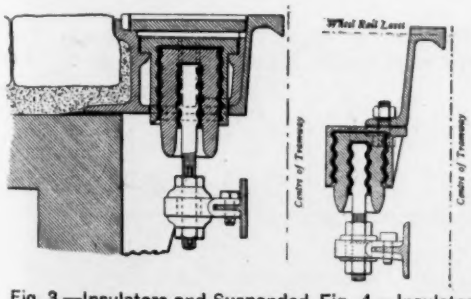


Fig. 3.—Insulators and Suspended Conductor Rails of Central Conduit in Washington, D. C.

Fig. 4.—Insulator and Hanger Used in Paris.

The problem of adapting the plow and track mechanism, to change from the overhead line to the conduit system, or vice versa, has been satisfactorily and carefully worked out on several different general principles. In America, where the conduit has been generally adopted in the cities of New York and Washington, the problem of a mixed line has received very little attention. In Washington, on two unimportant trolley lines, the cars run directly into the city on the conduit tracks, but the manner of making the change is crude and not worthy of attention. On the Continent there are a number of cases of this kind, and they are all worthy of attention, the problem having received in each case careful study. This, in the author's opinion, is only one instance in several, where European tramways offer now a much more fruitful field for study than American tramways, especially so to the engineer called upon to install a system in Europe under European conditions, and requirements.

The subject will now be considered in the following order: (1) The general type of conduit to be adopted; (2) the mechanical and electrical bases on which to construct conduit; (3) the special apparatus necessary for a mixed conduit and trolley line.

GENERAL TYPE OF CONDUIT.

The first question to be solved in a conduit construction is the conductor system, to which is intimately connected the manner of making contact. With the limited clearances in a conduit, there can be no other practical method than the one of installing rigid conductor-bars, to which the original Buda-Pesth conduit owes its success. Apart from that, it had no special feature which was of enough importance to make this line a success where others had failed. The conservatism not unnatural under the circumstances, shown in the construction of this road may be judged by the fact that 300 volts distribution was adopted, while now engineers have no hesitation in using 550 volts under similar conditions.

The next question is whether the conduit shall be side-slot or center-slot construction. If the engineer has his choice, he will undoubtedly adopt the latter type of conduit. On the Continent there is an objection in some of the cities on the part of the municipal authorities to the center-slot. Therefore, in Buda-Pesth, Berlin, and Brussels only the side-slot is allowed while in the cities of Lyons, Nice, and Bordeaux, the center-slot has been or is being installed. There are some short stretches of center-slot in Paris, but the reasons for this were exceptional, and in general this city may be classed in the first category also, 95% of the conduit mileage there being side-slot. Of the 45 miles of conduit electric railway constructed in four European cities and one American city with which the author has been associated as chief engineer, 30½ miles are of the center-slot, and the remaining 14½ miles are of the side-slot type. His original opinion of the greater advantages of the center-slot construction has been somewhat modified by experience, but he still believes that from an operating standpoint the center-slot is the better construction.

Fig. 1.—Side-Slot Switch.

Fig. 2.—Center-Slot Switch.

The inherent difficulty with the side-slot is the switch at the junction of two slots. Figs. 1 and 2 show the two cases. With the center-slot a comparatively light movable tongue can be hung or pivoted to the fixed tongue, its use being simply to guide the plow. With the side-slot the tongue is much stiffer and heavier, because it must also guide the wheels of the car and support them in one position; that is, the entire tongue is movable, and its upper surface from point to heel must be level with the wheel rail. At its point it should have a certain thickness to give mechanical strength. This should be not less than ½-in., which, added to the 1-in. minimum width of slot, gives an opening of 1½ ins., which is gradually reduced to 1 in. in a length of about 3 ft. In the center-slot construction the normal slot width of say ¾-in. is increased in a length of about 8 ins., and the maximum increase is about ¼-in. Another objection to the side-slot is that the flanges of the wheels throw water and mud into the conduit and on to the plow. Another is that the slot-rail being also a wheel-rail should have a vertical web, which diminishes the distance across from rail to rail on the line of their base-level, thus limiting the plow construction, and also making the conductor bars invisible from above, which renders the finding of faults more difficult. The principal trouble with the side-slot conduit is that connected with the switch, and it can be avoided by a special construction, which will be explained later. The advantages of the side-slot conduit are that the additional band of iron in the street required by the center-slot rails is avoided, and that the maintenance of the paving is thereby simplified, every joint of a rail with the paving being a source of weakness in the life of the latter.

MECHANICAL AND ELECTRICAL DETAILS OF CONDUIT CONSTRUCTION.

With the broad question of type of conductors and of position of the conduit settled, the design in detail of a conduit can be undertaken. The first matter is that of insulators and their mode of fastening. In the present state of the art there can be no question about adopting a porcelain insulator, or at least a material which has the same general characteristics. The first line equipped in New York city used a built-up insulator, a bolt being covered with an insulating compound; it failed, and the type of insulator which had proved so successful at Washington was adopted. In Brussels the type of insulator used is a bolt surrounded by a rubber compound. This is subjected to a severe piercing test with a Rumkorff coil before being accepted. These insulators have been fairly successful, but they are expensive, and they may also deteriorate by exposure to the atmosphere. The iron-clad porcelain insulator is strong, durable and cheap. There can be no hesitation about its use. The insulators should be vertical, so that they may not offer the chance for the accumulation of dirt, which can easily happen with one horizontally placed. The first Buda-Pesth road had this fault, but it was rectified in the later construction in that city.

Assuming a vertical iron-clad porcelain insulator, the method of attaching it to the conduit construction becomes important, the depth of the tube being somewhat dependent upon this. For the sake of simplicity they should be fastened to the metallic structure, which has the further advantage of keeping the conductor bars at the same distance from the wheel rails, except in the special case of a center-slot conduit where the yoke construction does not permit the carrying of the wheel rails. The extreme positions of the insulator are, first, with the upper surface of the insulator as near the street surface as it can be for mechanical protection, or say 2 ins.; secondly, with the upper surface of the cast-iron insulator cover bolted directly to the bottom flange of the slot-rail. Fig. 3 is an example of the former case. The insulator could have been reduced in vertical height so as to have carried the conductor bars higher, but this height is limited by the safe insulation distance required between these bars, and the slot-rail. Assuming this distance 3½ ins., the depth of yoke-seat diminishes it by about 1½ ins., leaving 2 ins. of air-gap, and the top of the conductor bars will be 10½ ins. from top of a 7-in. high slot-rail. Fig. 4 is an example of the second case with the same slot-rail. The insulator has been reduced in vertical height to the safe limit of mechanical strength. The corresponding distance to top of conductor bar is 14 ins., or a gain of 3½ ins. in the conduit depth for the first method of construction.

If the insulators are carried close to the street-level they must be protected by metallic covers, which in Europe are considered objectionable, and in some cases they are absolutely forbidden by the authorities, as in Paris. Therefore the second method is the only one that can be used in such cases. Perhaps it should be said that the insulators are protected by metallic covers in the second case; but these are paved over so that the street surface is in no way altered in appearance by their use.

The limiting conduit-depth being often a vitally important matter for the crossing of immovable sub-surface constructions, it will not be amiss to take up this question more in detail. As just explained, the conductor bar carrying height is arrived at by adding the depth of yoke-seat and the air-gap to the height of slot-rail. It is possible that the height so arrived at will not give the necessary distance for a vertically hung insulator and its mechanical protection. In this case the insulator determines the conductor bar carrying height. When this distance is determined, the height of bar itself, with the necessary clearance to the bottom of the tube, is added. The distance so determined gives the conduit depth. The clearance should be from 9 to 10 ins. to allow considerable room for water and dirt accumulation, which might otherwise endanger the operation of the road. But for relatively short distances the clearance can be reduced to 4 ins., where the conduit must be reduced in height from any cause. The author has used this distance in a number of instances, and knows from experience that it is

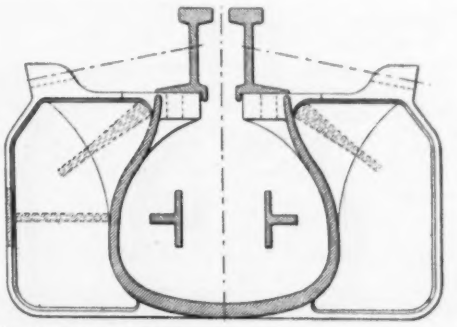


Fig. 5.—Special Shallow Conduit Used on the Pont de l'Alma, Paris.

*A paper read March 15 before the Institution of Mechanical Engineers of Great Britain.

practically acceptable. Such lengths of conduits need cleaning often.

Fig. 6 is an example of a shallow conduit, which was designed for use on the Pont de l'Alma in Paris. The depth to top of conductor bars is 8 ins., the height of bars 4 ins., the clearance 4 ins., and the thickness of the cast-iron continuous tube 1 3-16 ins., or a total height of about 17 ins. Fig. 7 shows a section of the insulator at the same construction, and Fig. 8, a plan view, gives the appearance of insulator cover in the street. This construction, while entirely practicable, had the inconvenience in this particular instance of a different carrying height of conductor bars from the regular construction of the conduit. Special means would have been necessary to

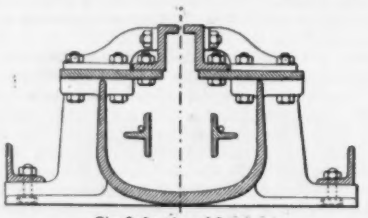


Fig. 6. Section of Casting.

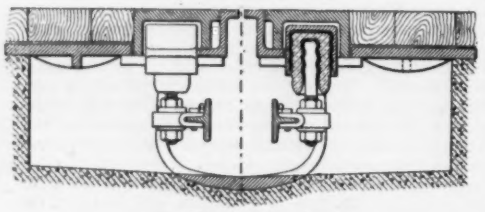


Fig. 7. Section of Insulator.

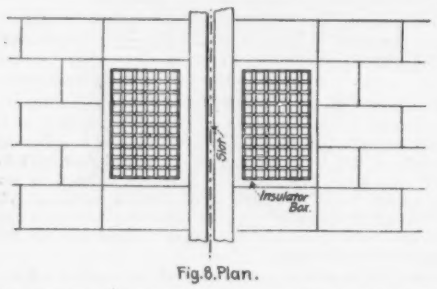


Fig. 8. Plan.

Figs. 6, 7 and 8.—Shallow Conduit Used on Pont de l'Alma, Paris.

raise the plow on this stretch of the road. A careful examination showed that the construction given in Fig. 5 was practicable by slightly cutting the masonry arches, which was adopted. The conduit construction in this last case has a total depth of about 22 ins., with a 6-in. slot-rail and insulators bolted to their bottom flanges. The conduit shown is in actual operation, and it can be safely recommended for special cases where the depth available is restricted. Fig. 9 is a view of this conduit during construction. One side of the cast-iron tubes is here shown specially curved to fit the center longitudinal arch, so as to avoid excessive cutting of the masonry. Fig. 10 is a view of another special construction over the steel railway bridge of the new line from the Gare St. Lazare to the Invalides. This conduit construction rests directly on the steel beams of the bridge, and spans from one to another of them; it therefore had to be in the form of a bridge itself, and a built-up beam construction was adopted. Where the regular yoke construction is used these project from 6 to 8 ins. below the tube depth, which is normally from 24 to 28 ins., depending upon method of insulator suspension, as already explained, giving, roughly speaking, extreme depth of metallic structures between the limits of 17 ins. (Fig. 6) and 36 ins. A careful examination of a proposed route should be made to see if the sub-surface constructions would permit the building a safe practicable conduit. With this broad question settled in the affirmative, there is no good reason why the expense and annoyance due to the removal and lowering of many sub-surface obstructions should not be avoided by taking advantage of the possibility of varying the depth required for the conduit. This only becomes a grave matter where the question may involve the complications due to changing the carrying height of the conductor bars to get the minimum depth of conduit. It may be suggested that the conductor bars could be carried at this minimum height for the entire construction, but an examination of Fig. 6 will show that it is only possible with a slot-rail of about 4 ins high, which is only practicable with asphalt paving.

It may not be amiss to say a few words about the switches, because in practice they are responsible for most of the interruptions in service. A misplaced switch has the result of guiding the car to one direction and the plow in another. The latter can become twisted in the conduit in a variety of ways, but with the too sure result of interrupting the traffic for a time, which, in the author's experience, may vary from 15 minutes to 2 hours. This bare statement is sufficient to demonstrate the necessity of so designing the switches, as to reduce to the strictest minimum the possibility of such accidents.

There are two distinct cases to be considered. The first is where the track is alone switched, the slot being continuous. Fig. 11 is a sectional view of a counterweight mechanism which can be adjusted to close the switches automatically, so that the track should be always open for the passage of the cars using the conduit track. Fig. 12 is a section of the same mechanism for the case of a slide-slot conduit. This precaution should always be taken, but it may fail. When this happens, it is usually due to something solid having fallen into the switch, and in consequence the tongues fail to return to their normal position. In the case of the center-slot construction, the danger of an accident can be avoided if the plows are hung on slides, which permit their traveling completely across the car. If the ends of these slides are left free of all obstructions from the truck or otherwise, the plow will drop off when the car has reached a certain distance on the wrong track. But the motorman generally perceives his error before that occurs, and simply stops and reverses the car, with the result of no interruption worthy of mention. Even in the worst case of losing the plow the car is simply "dead," and can be pushed in by the succeeding one. A trap should be placed conveniently at each such switch so that the plow can be taken out with no loss of time. If the accidents are only of this nature, they are not worthy of any serious attention. But in the case of the ordinary side-slot conduit, this result cannot be attained. The tongue there in one position covers the slot. In case of a false position of the switch, an accident will happen which almost surely must result in a serious interruption of the car-service. To avoid this difficulty, the author suggests that before the switches are reached, the slots should be deflected to the central position. Fig. 13 shows how it may be accomplished.

In the second case, with a slot-switch, the slot-tongue is a necessity. The author recommends for the side-slot conduit the same deflection of the slot to the central position. This serves the purpose of being able to avoid the side-slot slot switch, the constructional difficulties of which were enlarged upon in the first part of the paper. The danger of an accident with this switch is limited to the case where the point of the slot-tongue is directly in the slot. A "head-on" collision can then take place. But if the tongue is not thrown in the same direction as the track-tongues, the same slight interruption may happen as above explained—providing, of course, that the system of plow-slides there mentioned is in use. Fig. 13 shows the case of a side-slot conduit deflected to the center of the track at a slot switch. There are no mechanical or electrical difficulties in this case, the results of actual operation in Paris having demonstrated this statement. Fig. 16 is a view of a slot-switch operating mechanism. With one movement of the handle the three tongues are thrown in unison. For a dense traffic, it is advisable to put a switchman at such slot-switch points, to reduce to a minimum the danger of accidents and of interruptions of service. The author feels confident that the accidents at switching points will be almost negligible if the construction above indicated is followed.

SPECIAL CONSIDERATIONS FOR A "MIXED" LINE.

The first decision to be made for a line partly conduit and partly overhead is whether the plow shall be carried continually on the car, or removed and replaced at each junction point of the two systems. The latter is the simpler method. A roomy manhole containing a man to do this work is all that is needed; but it needs no argument to prove that it is an undesirable and expensive method to adopt. One is then impelled to a method whereby the plow is always carried on the car as the trolley is, to effect which the plow must be raised or lowered

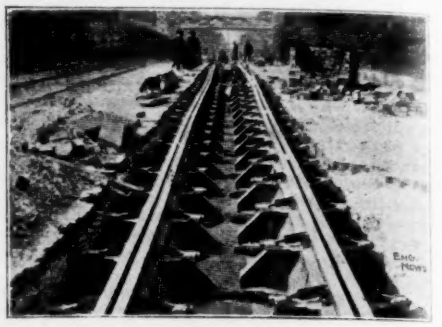


Fig. 9.—View of Special Shallow Conduit, Pont de l'Alma, Paris.

at the junction points of the two systems. The most natural and the neatest solution is to raise the plow through the slot with no special arrangement in the latter. This has been successfully done in Berlin and Brussels. In the former city the plow is equipped with a wheel at its lower extremity, which runs up an inclined plane; and the contact-shoes working on horizontal axes pass through the slot by being depressed to a vertical position. The wheel then runs in the groove of the wheel rail, and it is raised clear of the track by the turn on a crank given

Fig. 10.—Special Construction over Steel Railway Bridge, Paris.

by the motorman. At the same time the conductor loosens the bow sliding-trolley, and the operation is complete. The entire change can be made without stopping the car. No more perfect contrivance to accomplish this purpose could be devised. In Brussels the plow is raised by the motorman, the inclined-plane feature being discarded. A wheel-trolley is used so that a stop is necessary to catch the trolley wire.

Both of these systems involve the use of what the French call "clapets," which in English may be called "flappers." These are hung on horizontal axes around which is a coil spring, one end of which is fastened to the fixed axis and the other to the flapper. The springs make the flappers press against the conductor bars. The contact may be made on the vertical or the upper face of the bars according to the way the road is designed. The flappers are not thick, in fact the whole construction of the plow is very much cramped, for it must pass through the 1¼-in. slot. The plow of this form is withdrawn easily, but it has to be specially weighted to make it descend, for it has only its own weight to overcome the tension of the flapper springs, so that they will take the vertical position necessary to pass through the slot.

There could be no good reason for not adopting one of the above plow designs for a side-slot conduit, with 1¼-in.

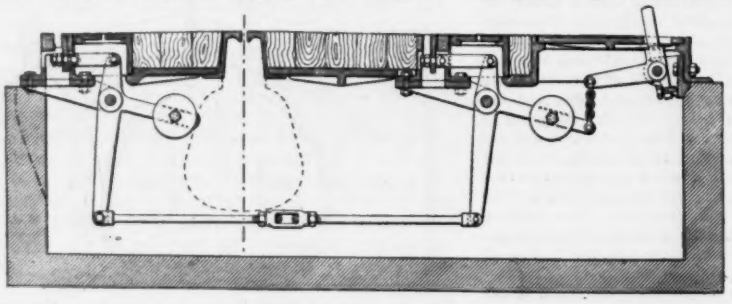


Fig. 11.—For Center-Slot.

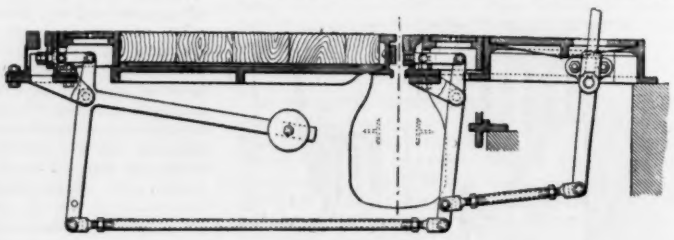


Fig. 12.—For Side-Slot.

FIGS. 11 AND 12.—CONTERWEIGHT MECHANISM FOR CLOSING RAIL-SWITCHES AUTOMATICALLY IN PARIS.

slot; for a center-slot, with ¾-in. width, their use is out of the question, if no other complications were involved; but the plow is one of the most difficult problems connected with the conduit system. The successful installation of two bare conductors in an open slot-conduit is not as serious a matter as to take the current from these bars through the slot to the car-motor. A plow must be strong enough mechanically to resist the shocks and wear and tear of ordinary usage, while not so strong but that it will yield before injuring the conductor-bar system in case of an accident. At the same time it must be electrically efficient under the most difficult conditions imaginable; bare collectors of current are connected to leads, which must be covered with insulation and mechanically protected by metallic wearing-plates, the total width of which do not exceed ½-in. with a ¾-in. slot, this being the ordinary condition with a center-slot conduit. The

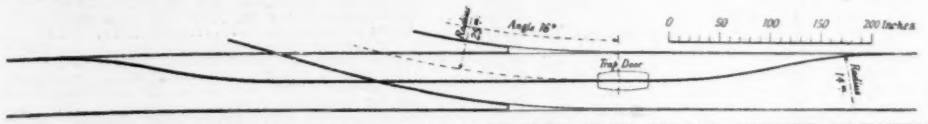


FIG. 13.—GENERAL PLAN SHOWING DEFLECTION OF SLOT FROM SIDE TO CENTER AT SWITCH.

plow is often drenched with water and covered with slime and mud, which run down its sides from the open slot. The conditions are certainly severe for an apparatus to carry successfully a 500-volt circuit. No form of plow yet designed is so perfect that any of its advantages may be sacrificed to gain other features, which can by any means be dispensed with. In the author's opinion the design of the plow should have the first consideration, and the conduit and special apparatus connected with a road should be built "around" the plow as the base.

The flapper form of plow construction is weak mechanically. The friction of, and shocks due to, uneven joints in the conductor bars tend to twist the flappers about their horizontal axes. At the points where the bars are interrupted, such as at slot switches or at crossings, the shocks of this nature are very considerable. In actual practice the flappers are often wrenched off at these places. When released from their fixed position against the conductor-bars the flappers take a position which is variable, depending upon the tension of the coil springs, which naturally cannot always be the same. A warped surface extension piece has to be fastened to the ends of the conductor bars to guide the flappers to their normal position against the bars. These pieces give considerable trouble, and their use should be avoided, if possible. This form of construction does not permit the use of a fuse to connect the contact-shoe with its lead; consequently a short circuit in the body of the plow, not being protected by the car fuses, would short-circuit the line, and thereby stop the car traffic until the faulty plow could be discovered and raised out of the slot. The author believes it to be indisputable that other forms of plows are much more efficient, but none of them have the advantage of being able to be withdrawn from or lowered into the conduit without a special trap construction at a fixed point. Nevertheless, if the reasoning above given is true, one of these types of plow should be adopted, and it could be only a question of choosing the best existing one and improving it.

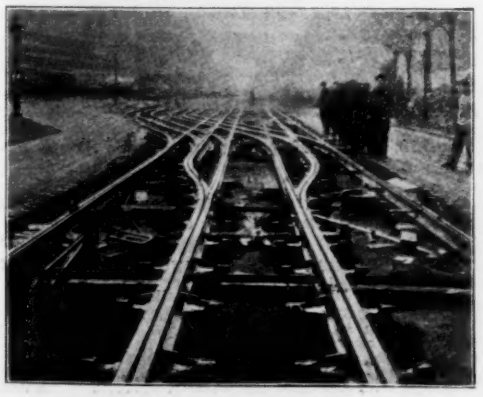


Fig. 15.—Deflection of Side-Slot to Center-Slot.

In the light of present experience the best plow is one having soft cast-iron shoes, pressed lightly against the vertical faces of the conductor bars by semi-elliptic springs horizontally placed. The shoes preferably should be carried by horizontal links, which take all the shocks to which they may be subjected, leaving the springs free to do the work only of pressing the shoes outwardly. In this way the risk of deforming the springs is avoided. The links should be constructed so as to limit the outward course of the shoes. The conductor bars at switches and crossings are simply curved slightly outward. The shoes are connected to the leads by copper fuses. This plow construction is simple; in actual results it has proved itself to be efficient. It certainly is an improvement upon the "flapper" type.

The trap construction in its simplest form would be one in which the lids required to be lifted before the arrival of the car, and to be put back in place after its departure. This would be rightly considered a crude and laborious operation. Fig. 17 shows a form of trap which is operated after the car has reached its position. One throw of the lever opens the trap, which is so counterweighted that the effort necessary for this is almost inappreciable. This trap construction has given excellent results in France, where 40 of them are in operation. Where the flapper form of plow is used, the plow is lifted by means of an apparatus similar to a brakestaff, which is placed on the platforms. The plow is connected to this staff by means of cables which are guided by conveniently located sheaves. On account of the width of slot of the side-slot conduit, made necessary by the fact that it must be wide enough for the wheel flanges, the flapper form of plow has only been adopted for this construction of conduit. The plows are raised in guides attached to the side frames of the truck. In Brussels and Berlin the plows are not mounted on slides permitting a laferal motion across the car. The two slots of a double-track construction being located on the interior rails, it is necessary to carry two plows with a raising and lowering mechanism for each. If the requirements of the road demand cross-over switches from one track to another, a third conduit is necessary for a short distance at such points. The deviation of the slot to the center with the necessary plow-carrier construction entirely obviates the difficulty of two plows and of a third conduit.

The use of the slides seems to the author to be a valuable feature of conduit electric railroads for the various reasons that have been given in the paper. Therefore, the following explanation of a raising and lowering device for the plow, which will permit this sliding feature, is given in detail. Fig. 18 gives three views of such an apparatus. A are the side bars, B the top bar of the truck, and C the brake rods, which must be placed outside the wheels as here shown. D is the plow shown in position on the side-slot conduit; it slides from this position to that of (1) on the center slot, or of (2) the position of the slot of the other track when crossing from the interior conduit on one track to the similarly placed conduit on the other track. The slide-ways are shown by the bars E. The bars F prevent the plow raising or tilting in the conduit, except in the central position (1), where the casting G, held in position by the lock H, performs the same function. The sliding-bars are held in position by the steel castings I. The projecting central piece J, braced as shown, holds the plow in its raised position. The whole apparatus is supported by the channel beams K, which are bolted to the side-bars of the truck. In this way the vertical variation in height is limited to the small movement in the journal-box springs of the truck. The plow is raised in the following manner: The fixed screw L is turned by means of a removable crank placed at M; the block N marks the course from one end of the screw to the other. In the figure the block is in its position with the plow raised. This piece carries the two rollers O, over which heavy link chains run. The latter are stationarily fixed at one end, P, and at the other end to the casting G. The piece G is raised by an amount which is twice that of the course of the block N. The latch R automatically locks the block N in place when it reaches the end of its course. This prevents the trepidation of the truck from lowering the plow when it is in its raised position for the overhead-trolley section of the road. The box S covers the double-pole switch which puts the car-leads in circuit, with the overhead or the conduit line as the case may be. This is done automatically with the raising or lowering of the plow by means of the rod T, which is moved by the block N when this is near the end of its course in each direction. Externally, the whole apparatus is nearly invisible. Fig. 19 is a side view of the truck so equipped.

The author is indebted to Mr. E. W. Mix, the Chief Engineer of the Société des Etablissements Postel-Vinay of Paris, for his invaluable assistance in the design and manufacture of the apparatus above described. That it has been successful is largely due to his efforts.

It is a good plan to form the piece M so that it will only fit a controller handle, which can only be removed from the controller on the "off" position. In consequence, if the handle is used to raise or lower the plow there can be no movement of the controller until the operation is finished. Generally there are two traps at the junction points of the two systems, one for each track. The conductor of the car can operate the trap, but it is preferable to have a man specially stationed for the purpose, if the car traffic is at all frequent. In practice the operation is as follows: When the car has stopped with the plow over or under the trap (a mark on the track gives to the motorman the exact position to stop) the motorman gives his controller handle to the trapman who opens the trap, and lowers or raises the plow, closes the trap, and returns the handle to the motorman. At the same time the conductor lowers the trolley from or raises it to the trolley wire. The whole operation takes on the average 10 seconds when the men become accustomed to it. If these junction points coincide with regular stopping places to load or discharge passengers the loss of time due to this operation is inappreciable. The only arcing at the conductor bars and at the automatic switch, S (Fig. 18), is that due to the lighting circuit. This is too small to have any injurious effect upon the plow-shoes, and the construction of the switch with a quick break is such as to remove any danger there also. If electric heaters should be used requiring rather large currents it might be necessary to cut them out of circuit during this operation. The car wiring for the mixed system is only slightly more complicated than for one system alone. The conduit circuit being completely insulated the ground wire must be removed from the controller. Two wires are run from the controller to two points on the double-pole switch S. These two points are thrown in by the switch with one pair of points connected to the two plow leads or with another pair connected to the trolley pole and the earth.

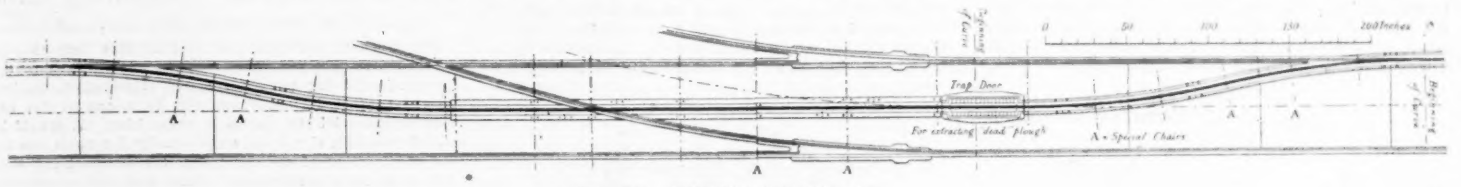


FIG. 14.—DETAILS OF FIG. 13.

In the electrical apparatus the only special precautions to take due to the use of conduit is, first, to have the field coils insulated for 500 volts. With an overhead line the difference of potential between the field and the frame of the motor is that due to the drop in the fields. But with the conduit it can happen that one pole of the conduit circuit is grounded, and that the fields are directly connected with the other pole. This would give 500 volts difference of potential between the frame of the motor and the field winding. All standard motors should

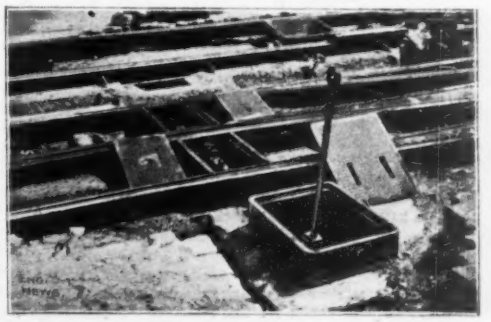


Fig. 16.—Tramway and Conduit Switch.

stand this condition, but it should not be omitted to be specified by the buyer. Second, when electric brakes are used, special insulation precautions are vitally necessary for the brake coils. A grounded conductor bar can subject these to 500 volts pressure during the entire time the car is on the conduit section. Not only is the annoyance due to burning up of the coils to be considered, but also that due to the short-circuiting of the line. An interruption of this kind is overcome by lowering the line voltage by means of a rheostat at the station, so that a current the amount of which is controllable at the switchboard may be sent through the fault. This excessive cur-

rent will burn the plow fuses, thus clearing the line at the expense of leaving the faulty car "dead," to be hauled in by the succeeding one.

With a combined trolley and conduit line the conduit section should have a separate circuit. It may be possible to operate it successfully with a grounded return, but few engineers would care to propose it. It is much better to increase the operating factor of safety by having both sides of the circuit insulated. In case the conduit

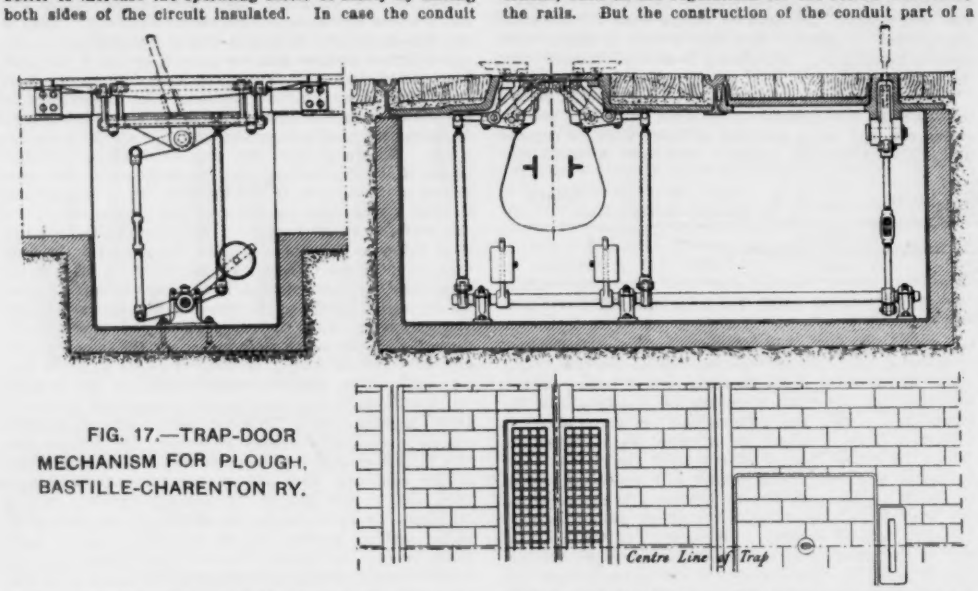


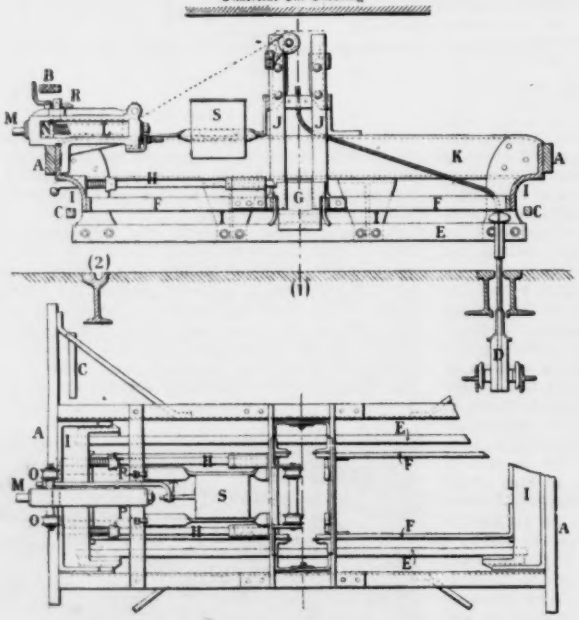
FIG. 17.—TRAP-DOOR MECHANISM FOR PLOUGH, BASTILLE-CHARENTON RY.

section or sections are reasonably close to the power station, this may be done with a separate dynamo located there for the conduit circuit or by means of a motor generator. If the cost of the leads to the conductor rails from the station is excessive, the motor-generator set may be stationed near the conduit section, and operated from the overhead circuit. The proper solution may be one of many different ones depending upon the local circumstances governing a specific case. As a result of actual tests it has been found that the conductor bars of mild steel electrically connected with two bonds at each joint have a carrying capacity of about 1-11th of copper bars of the same cross-section. These bars can be largely increased in electrical carrying capacity by attaching to them bare copper cables for this purpose. It can be readily seen what an economy this method affords over that of laying insulated cables in ducts. The cables are electrically connected to the bars at very short distances apart to avoid electrolytic action between the two metals.

COST OF CONDUITS.

The question of the cost of conduits must be treated in a general way, local circumstances being such a large factor in the determination of cost that no other method is possible. The side-slot conduit can be built for about $2,500 less per mile of single track than the center-slot. In the special work there is an economy in the side-slot also as ordinarily built, as there are fewer frogs with three rails than with four. But if the slot is deflected to the center, as has been recommended in the paper, the economy cannot be realized; on the contrary, the cost will be somewhat greater, due to the cast-steel deflecting pieces and the bent slot-rails. It is generally stated that a conduit road costs twice as much as an overhead trolley road. This statement may be misleading, owing to the fact that an overhead trolley road may be very variable in its cost, depending upon pavement requirements, overhead construction adopted, and many other local conditions, such as the regulations for the return current by the rails. But the construction of the conduit part of a road is quite independent of these factors, that is, for an overhead trolley road which would cost $25,000 per mile of single track; it is quite probable that the same road with the conduit construction would cost $55,000 for the same length, that is, the conduit properly speaking would cost $30,000 in excess of an overhead trolley road. If the overhead trolley line should have a first cost of $50,000 per mile of single track, there is no reason why the use of a conduit on such a line would double the cost as in the first instance. Roughly speaking, the cost of a conduit in this latter case would be $80,000. To arrive at an approximate comparison of the cost of the two constructions, it is fair to assume that the cost of paving and of the wheel rails is the same in both cases. For the conduit there should be added per mile of single track approximately the following material and labor: 105 tons of slot-rail, 40 tons of conductor-rail, 210 tons of cast iron, $600 excess for bolts, etc., porcelain insulators $175, 1,400 cu. yds. excess excavation, 1,200 cu. yds. of excess concrete, $3,000 excess labor for track-laying, $2,000 sewer connections. Crossings, turnouts, and special track work in general cost; 200% more on an average for the conduit than for ordinary track. A cost which is wholly indeterminate is that of removing sub-surface obstructions. This, as has been explained, can be often reduced by varying the conduit depth to suit special cases.

Considering alone the items above enumerated they will amount to between $27,500 and $30,000. Deducting the cost of an average overhead construction, it can roughly be said that a conduit road will cost from $25,000 to $27,500 more per mile of single track than a trolley road under the same conditions, to which should be added the increased cost of special track work and the removal of underground obstacles. Under ordinary conditions the difference in cost will vary between the limits of $35,000 and $45,000.



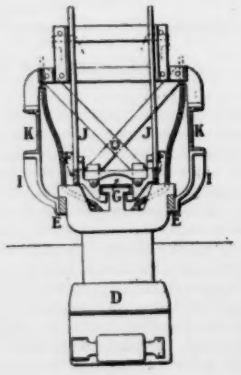


FIG. 18.—PLOUGH, WITH RAISING AND LOWERING DEVICE.

DETAILS OF COST IN THE UNITED STATES.

The following table gives the actual cost per single track mile of the conduit roads installed by the author in 1895-'96 for the Metropolitan Railway Co. of Washington, D.C.:

COST OF METROPOLITAN RAILWAY CO., WASHINGTON, D. C.

		Total.
Straight track, 101,660 ft.; curved track, 9,190 ft. 110,850 ft., or say 21 miles of single track.		
Rails and splice bars:		
Wheel rails, per ton	$28.05	
Slot rails, per ton	31.28	
Guard rail for curves, per ton	46.24	
Conductor rail, per ton	40.88	
Joints complete, each	1.20	
Cost per mile of single track		$9[illegible]1.54
Cast iron (yokes, insulator frames, covers, etc.) 215.5 tons at $28.19 a ton		6[illegible]4.75
Bolts, tie-bars, clips, etc.		1,[illegible]8.82
Bonds for conductor rails		476.04
Track-laying (all labor and hauling)		2,8[illegible]1.97
Temporary track.		102.04
Excavation, all kinds except cable ducts, 2,507 cu.yds, at 95 cts. a yd.		2,3[illegible]3.34
Sewer pipes laid and brick work for duct manholes		4[illegible]3.01
Cable ducts: 12-way duct 10,616 ft. at $1.20		
8-way duct, 41 " " .88		
4-way duct 21,354 " " .55		
2-way duct 113 " " .35		
	$23,786	1,092.65
Excavation for cable ducts, 9,207 cu. yds, at 83 cts. a yd., $7,447.74;		355.14
Concrete, first grade, conduit (1 bbl. Portland cement, 12 ft. sand, 22½ ft. broken stone), 765 cu. yds. per mile.		5,422.62
Concrete, second grade, for paving base, etc. (1 bbl Cumberland cement, 10 ft. sand, 20 ft. broken stone), 514 cu. yds. per mile at $4.52		2,238.74
Paving:		
Stone, old setts, 42,126 yds., 80 cts.	$33,269.07	
Asphalt, 91,716 yds. at $1.50 a yd.	134,650.67	
	$157,919.61	7,996.20
Special track work and curves		3,805.04
Extra bills of street contractor		1,163.20
Removal of sub-surface obstructions		3,240.09
Total cost per mile of single track		$48,336.47

The metallic structure cost less at that date than it would now. The temporary track is a very low item, the authorities having permitted a flat strap-rail to be laid on the pavement (mostly asphalt) by means of flat tie-bars with special seats at their extremities. It should be stated that this city is an exceptionally favorable one for the construction of conduit roads, the streets being wide and with little traffic upon them, and the supervision being that of the thoroughly trained engineers of the United States Army.

The author has been given a pamphlet containing some diary notes kept by Mr. William C. Gotshall, Engineer-in-Charge of Construction of the Second Avenue Railroad Co. of New York. The pamphlet concludes with the following estimate of the cost of this road per mile of single track. It should be stated that this estimate is not Mr. Gotshall's, but the work of the compiler of the pamphlet:

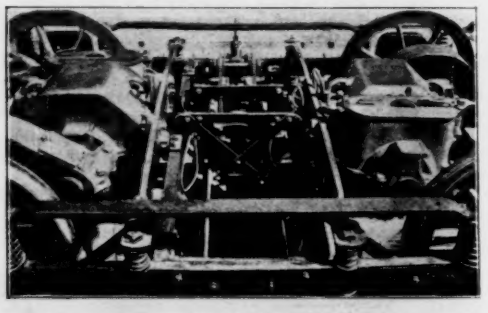


Fig. 19.—Truck of Car Equipped with Plough Apparatus.

TOTAL COST PER MILE OF SINGLE TRACK, OPEN Conduit System, Second Avenue Railroad Co.; Compiled from Diary of W. C. Gotshall.

Labor,* at $7.59 per lin. ft.	$39,720.98
Insulators at $1.40 each	696.53
Iron work, excluding yokes, $1.83 per lin. ft.	6,684.25
Cost of iron yokes, 224.7 tons at $25.30 a ton	5,678.68
Concrete, ⅝-cu. yd. per lin. ft., $2.04 a yd.	3,929.38
Haulage on yokes and iron work	569.03
Total, without paving	$57,551.53

*Digging trough, removing old track, repairing concrete, removing excess of dirt, and hauling all track work.

The above total does not include cost of feeder duct.

In comparing this cost with that of the Washington conduit, it should be borne in mind that the items of cost of special track work, feeder ducts, paving, bonds, sewer connections, temporary track, are not included in this estimate, while they are in the Washington costs.

The cost of concrete is put down at $2.04 per cu.yd. This low cost is evidently an error of compilation. Other information in the pamphlet seems to prove that this cost should be from 2½ to 3 times this amount.